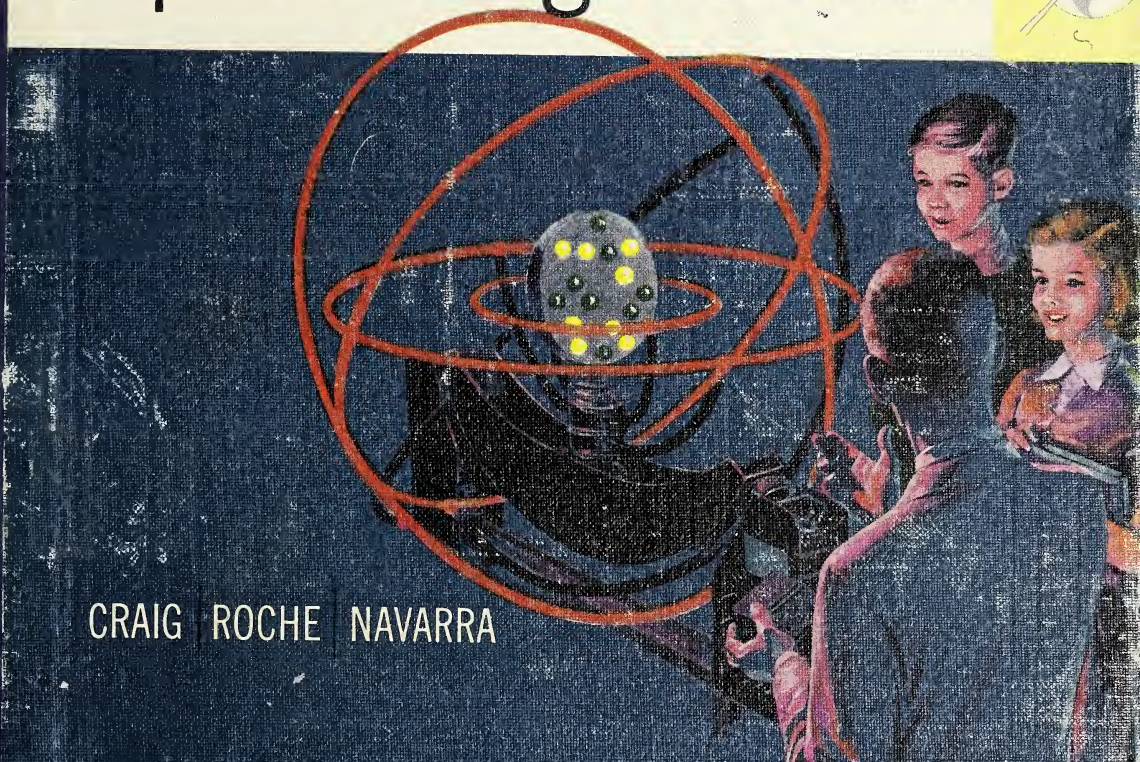
SCIENCE TODAY AND TOMORROW

Teachers' Edition

Experimenting in Science



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Experimenting in Science

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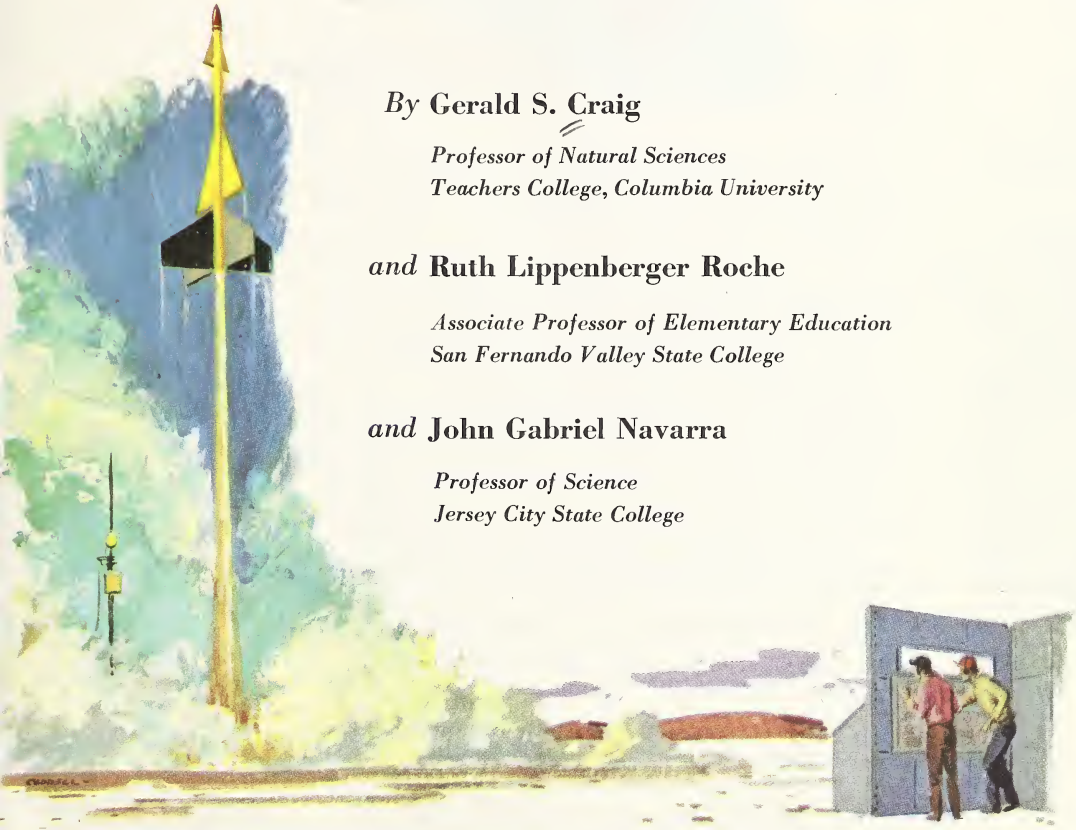

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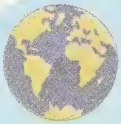

SCIENCE TODAY AND TOMORROW

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A Teachers' Manual accompanies each book

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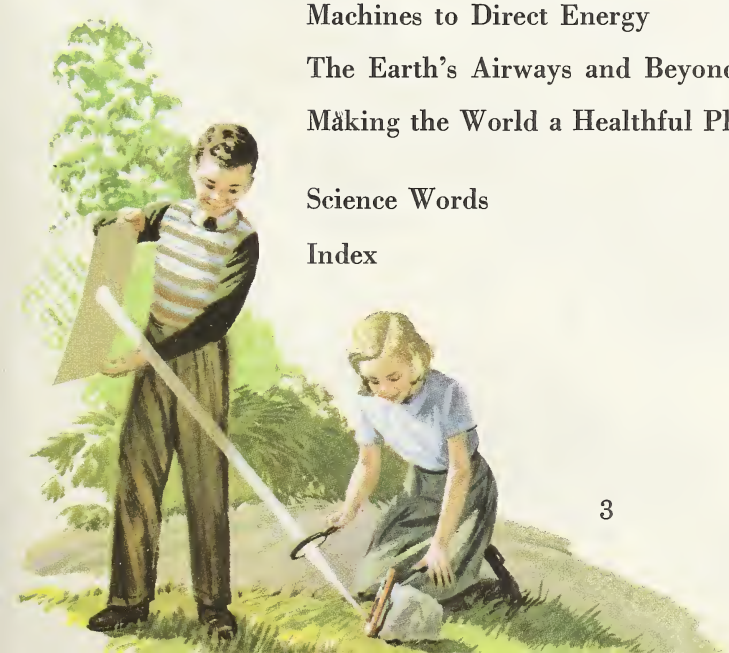

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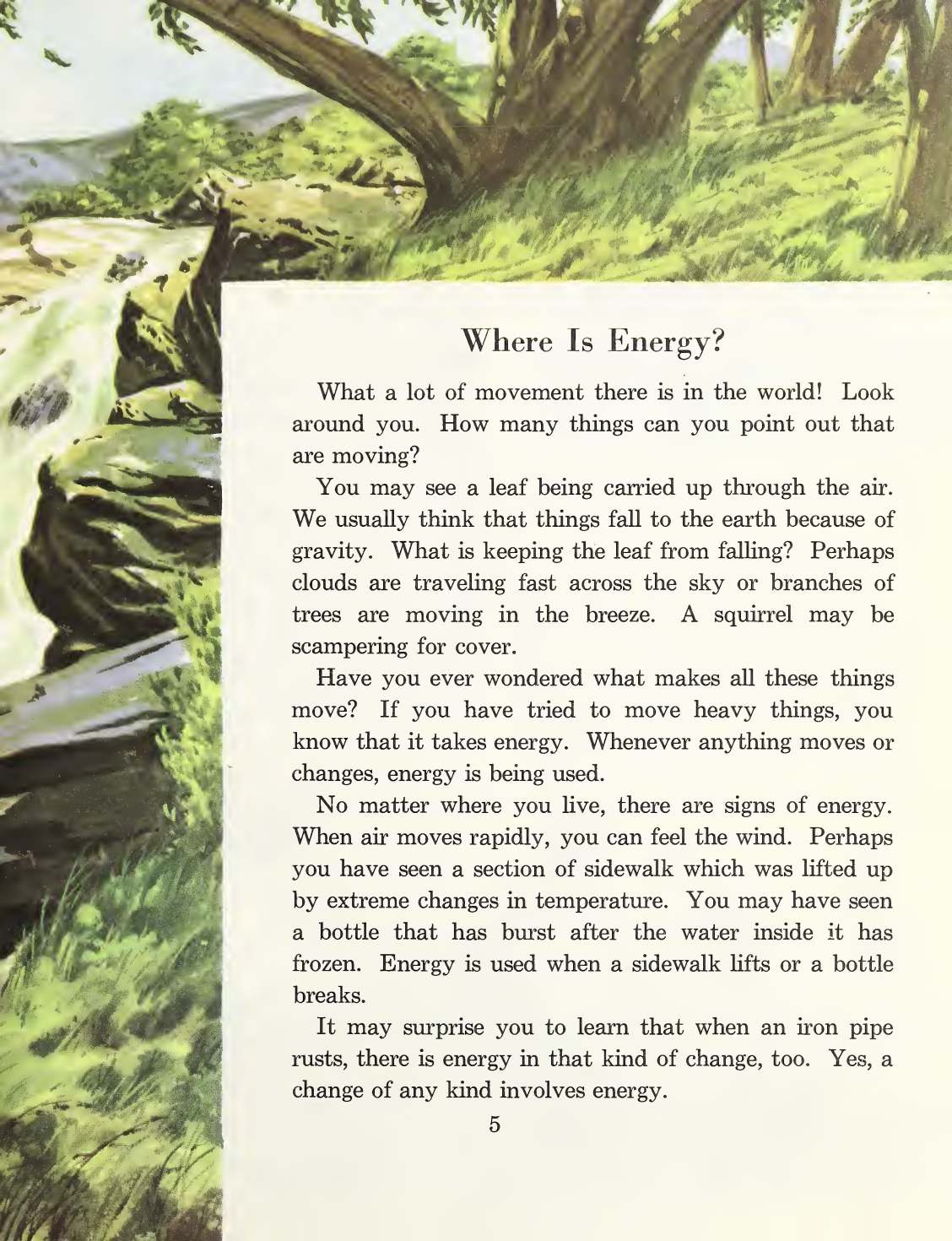
Energy Everywhere



Where Is Energy?

What a lot of movement there is in the world! Look around you. How many things can you point out that are moving?

You may see a leaf being carried up through the air. We usually think that things fall to the earth because of gravity. What is keeping the leaf from falling? Perhaps clouds are traveling fast across the sky or branches of trees are moving in the breeze. A squirrel may be scampering for cover.

Have you ever wondered what makes all these things move? If you have tried to move heavy things, you know that it takes energy. Whenever anything moves or changes, energy is being used.

No matter where you live, there are signs of energy. When air moves rapidly, you can feel the wind. Perhaps you have seen a section of sidewalk which was lifted up by extreme changes in temperature. You may have seen a bottle that has burst after the water inside it has frozen. Energy is used when a sidewalk lifts or a bottle breaks.

It may surprise you to learn that when an iron pipe rusts, there is energy in that kind of change, too. Yes, a change of any kind involves energy.

Energy is one of the most important things in our lives. Think what the world would be like without energy. It would be a lifeless, cold world in which there would be no light. It would be completely dark. On such a dead world there would be no sound. Nothing would move. There would be no wind, no clouds, no rain, and no snow. In fact, there would be no weather at all if there were no energy.

How Do We Use Energy?

There are many signs of energy. We have talked about some of these signs. Energy sets things in motion. It is used when things change. In how many ways are you using energy at this moment?

Kinds of Energy

Even before you wake up in the morning, you use the energy of your muscles. All the time that you are asleep you never stop moving. Your heart muscle is always moving. Muscle energy keeps your heart beating and the blood traveling through your veins and arteries.

The energy in your muscles keeps your lungs in motion, too. If your lungs were not always in motion, you would not be able to breathe. You use the energy of your muscles to get up, to move around, to work, and to play. You use muscle energy every minute of the day and night. Another name for the energy of your muscles is chemical energy. Chem-

ical energy is stored in food. When you eat food, its energy becomes part of the muscles of your body.

If you have helped your mother with her cooking, you may already be familiar with chemical energy. Have you ever put a spoonful of pancake batter on a hot griddle and watched what happens? The heat of the pan brings about chemical changes in the batter. The energy of the chemicals in the mixture causes it to change in size and shape as well.

You can try an experiment with chemical energy by combining baking soda and lemon juice. Squeeze the juice of a lemon into a glass. Then add a half a cup of water and a teaspoonful of baking soda. When baking soda and lemon juice are mixed together, carbon dioxide is formed. This gas causes the liquid to foam up in the glass. Remember that whenever anything moves, energy is being used. Do you see the motion of the liquid after baking soda has been added?

Something else happens when soda and lemon juice are combined. If you listen carefully, you will probably hear a slight fizzing sound in the glass. Some of the chemical energy has been changed to sound energy. Yes, sound is energy, too.

One of the first kinds of energy you made use of when you got up today may have been sound energy. Perhaps the ding-a-ling of an alarm clock woke you early this morning. The ringing of the alarm was sound energy. You may not think that that was much energy. But it woke you up!

We use sound energy in many ways. Think how many things you

can identify by the sounds they make. Whenever you speak, you are using muscle energy to produce sound energy.

When you rub your hands together on a cold day to keep them warm, you are using muscle energy to produce still another kind of energy. This kind of energy is called heat. A saw becomes warm in much the same way when it is used to cut wood. As a saw rubs against wood, heat is produced.

To produce heat energy, you may use some kind of fuel, such as wood, coal, oil, or gas. If you toasted bread for breakfast, the bread was toasted by heat energy. The red-hot wires of the toaster supplied heat, which browned the bread. Where did the heat come from?

Do you remember connecting the plug on the cord of the toaster to the electrical outlet on the wall? Electrical energy passed through the wires of the toaster and produced heat. A toaster changes electrical energy to heat energy. What else can you name which changes electrical energy to heat?

Other Kinds of Energy

We have talked about energy in chemicals, in your muscles, and in electric wires. Do you think that there is energy in an object such as a ball?

You know that you need energy to throw a ball. But does the ball itself have any energy of its own? Perhaps you have had the misfortune to break a window during a game of baseball. If so, you know

that when a ball is moving, it may have enough energy to shatter a pane of glass. This energy of moving objects is sometimes called mechanical energy. Later you will read how machines have been developed to make use of the energy of moving air and moving water. Mechanical energy is important to us in our daily living.

Perhaps it has never occurred to you that light is a kind of energy, too. If you were not using light energy, you would not be able to read the words that are printed on this page.

Light energy has become so necessary to us that we manufacture light in our homes every night. Each one of our electric lights changes electrical energy to light. It is only through the production and use of light energy that people are able to read, sew, or work after nightfall.

By day most of our light energy comes from the sun. Scientists tell us that the light of the sun is produced when atoms of hydrogen gas combine. This means that the sun's energy is really atomic energy. Directly or indirectly all the kinds of energy we have been talking about probably come from the atomic energy of the sun.

What Is Energy?

Electricity, sound, light, and heat are all forms of energy.

Can you point to something and say that this is electrical energy or heat energy? How would you describe electrical energy or heat energy? You might try to tell someone what it looks like.

Now this seems rather peculiar: we can see what energy does, but no one can hold it up to show the rest of us. Yet there is much energy around us.

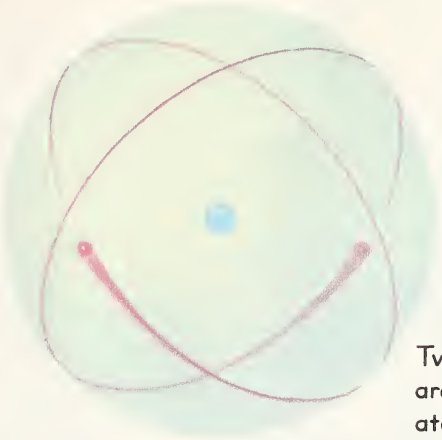
Probably you have held your hand near an electric stove when it was turned on. You could feel the heat. We know that the heat is due to electrical energy. But do we know what electrical energy really is?

What Is Electrical Energy?

We may hold up a dry cell and say, "Here is electrical energy. We have electricity in this dry cell." When we take a dry cell apart, we will find a zinc can, a carbon rod, chemicals called ammonium chloride and manganese dioxide, and also blotting paper. But can we find any electricity? All we can find will be the zinc, the carbon, and other chemical substances.

Still you insist that there is electricity in a dry cell. You know that if you connect a light bulb and socket to a dry cell by means of wires, the bulb will light. You may say, "Electrical energy lights the bulb." You are right. It is true that we can find no electricity in a dry cell. But when wires are connected to it, electricity flows along the wires.

Here is one reason why you cannot find any electricity when you take a dry cell apart: electricity cannot flow unless there is a pathway along which it can move.



Two electrons spinning around the center of an atom of helium

By properly connecting wires to a dry cell, you form a circuit. This provides a pathway. If you include a light bulb and socket in the circuit, the electrical energy will move from the dry cell along the wire and light the bulb.

After you have taken a dry cell apart, can you still get electrical energy from the chemical substances of which it is made? It would be difficult to do so. You have destroyed the dry cell. In order to get electrical energy, the chemical substances have to be put together and used in a special way.

Atoms and Electrons

Men and women who have studied electrical energy think that electricity occurs because of the way that atoms are built. You may already know that scientists have had a theory for many years that everything is made of small, moving particles called atoms. A very small piece of wood is made of millions and millions of atoms. A piece of glass or anything else you could name is also made of large numbers of atoms.

It seems hard to imagine that all the millions of atoms in a small piece of wood are moving very fast. But scientists think that atoms keep moving all the time and that they contain a great deal of energy.

As each atom moves, the parts of the atom move also. The outer parts of an atom are called electrons. It is believed that electrons move rapidly around the center of each

atom, but some electrons move from one atom to another.

Have you ever scuffed your feet across a rug on a dry day and then touched something? As you touched a doorknob, you may have got a "shock." When you scuff your feet across a rug, you rub electrons off the rug. The electrons collect on your body. Then as you touch a doorknob, the electrons move from your finger tip to the knob. You feel a shock and may see a spark.

We are told that electrical energy is a movement of electrons. When a circuit, or pathway, is provided from a dry cell, electrons move along it. They move from atom to atom in the wires of which the circuit is made. This is not the same kind of movement that you feel when you touch a doorknob, but it is a rather regular movement. People usually call such a movement of electrons a current of electricity.

What Does Energy Come From?

You might like to examine the zinc covering of an old dry cell. If the dry cell has been used a great deal, the zinc covering may be quite thin. There is probably a lot of white powdery material on the inside of it. If you have a new dry cell and an old dry cell, you might compare the zinc covers.

The zinc covering of a dry cell which has been used a great deal is much thinner and lighter than that of a new dry cell. This is because the zinc has been used as a fuel. Energy is released when we use a fuel properly. When zinc is used as a fuel, electrical energy is released.

It may be a little difficult for you to think of zinc as a fuel. When you think of fuel, perhaps you think only of wood, coal, oil, or gas. However, zinc is also a type of fuel, from which energy can be released.

If zinc is to be used as a fuel, it has to be put together with other chemical substances in a special way. It also has to be used in a special way. The zinc is used as a fuel by making it a part of a dry cell and then placing it in an electric circuit.

You cannot release energy unless you use fuel in a special way. Each fuel has its own particular way to be used. Take a piece of coal and crack it with a hammer. Is there any energy released from the coal? No. You can break large pieces of coal into small bits of coal dust. The only thing you will have is coal dust. You use energy to smash the coal, but you do not release any energy from the coal in this way.

You are already familiar with the way in which coal must be used to release its energy. Of course you must burn the coal. When you burn coal, heat energy is released.

What do you have left when you have used the coal as fuel? The

only thing left that you can see is the ash of the coal. While the coal is burning, heat energy is being released. The coal is destroyed when it has been completely burned. It cannot be used as fuel again. In place of the coal destroyed there are heat energy and ash.

Energy from the Sun

The sun has probably been shining on the earth from the very beginning of the earth. It has kept shining through many, many centuries.

For a long time man has recognized the importance of the sun in his life. Many early men worshiped the sun. The night, to these early people, was a time of great danger. They waited anxiously for the light of day.

Long before man knew much about the sun, he was able to use its energy. He used the energy from the sun to dry his food and to dry hides from which to make clothes. He used the sun's energy to keep himself warm. It is only within the last few years, however, that man has discovered how the sun's energy is produced.

Scientists who have studied the sun tell us that its energy is produced from atoms. We are still learning about the atomic energy of the sun.

Drying food in the sun

An early use of coal

As we read, we shall see how the sun supplies the driving energy which produces winds, rain, and the weather in general. The changes in seasons are really changes in the amounts of energy which reach each region of the earth from the sun.

Man has known for a long time how important energy is to him. He has searched for ways of producing energy. This search has been mainly one of seeking fuels and better ways of using them.

Energy from Coal

Ancient people knew about the material called coal. However, it was a long, long time before someone discovered that this black "rock" would burn.

Can you imagine how the discovery that coal could be used as a fuel was made? Perhaps a piece of coal happened to be left near a wood fire. Just by accident it may have started to burn. Maybe the discovery was made in some other way.

The first written description of coal as a fuel was made over two thousand years ago. A Greek writer described coal as a black rock that would burn like wood.

The early Romans used some coal. However, wood was the fuel used by most people for thousands of years. It was less trouble to gather wood than to dig coal, and it was easier

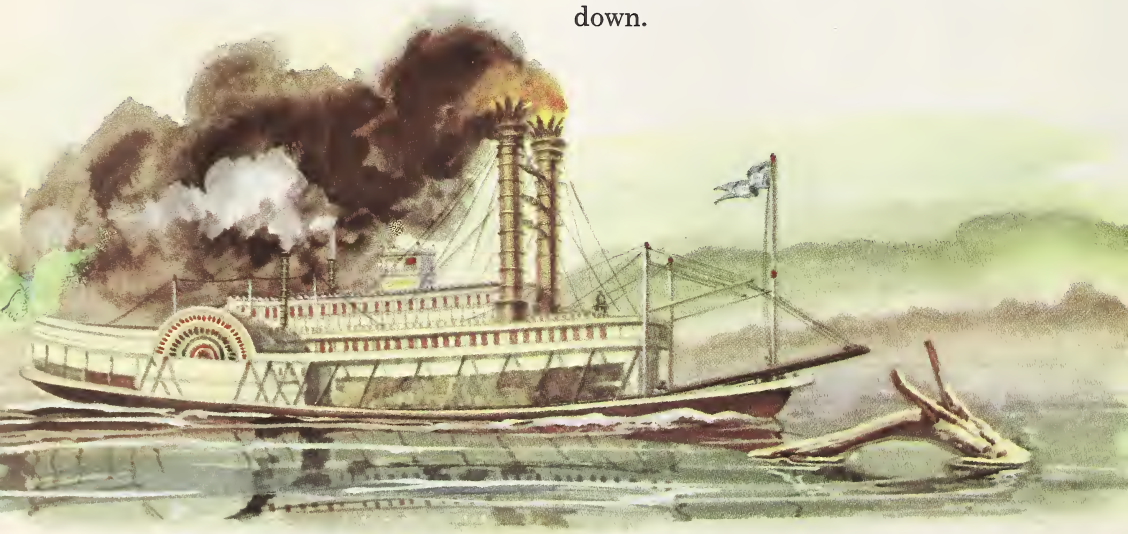
to kindle a wood fire than a coal fire.

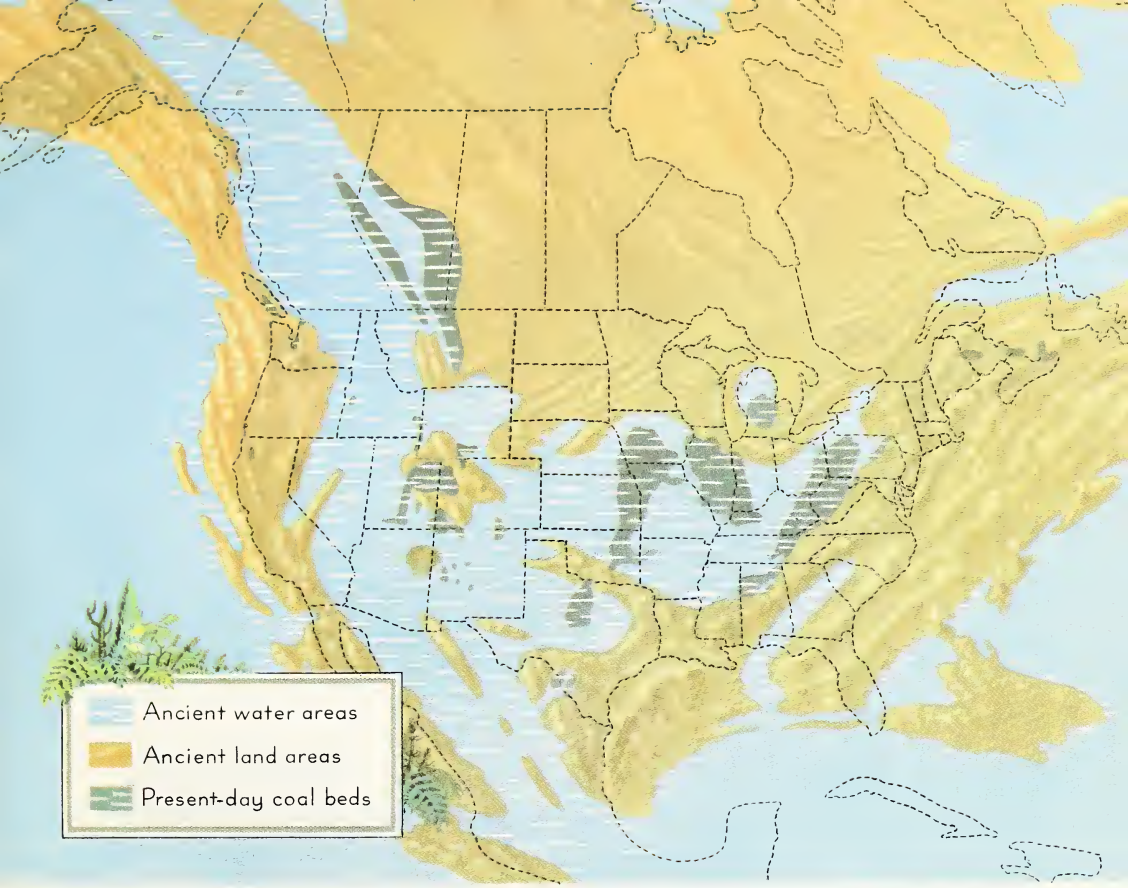
Gradually men began to have need for much hotter fires than they could get by burning wood. For example, blacksmiths needed to heat iron so that it could be shaped and worked. To heat the iron, they needed a hotter fire than they could get from wood. Coal, when used as a fuel, would produce hotter fires than wood. So blacksmiths used coal to produce the heat which they needed to shape the iron.

The invention of the steam engine also showed people the importance of coal as a fuel. When the steam engine was used in boats, wood was first used as fuel. But steamboats need a kind of fuel that will not take up too much space. The fuel must also produce a hot fire. One of the most useful things about coal is that it has a great deal of energy stored in a little space.

"Stored Sunlight" in Coal?

The coal we are using today was formed many millions of years ago. Long ago in the history of the earth large accumulations of plant material occurred. It was then that the greatest coal beds were laid down.





Long before people lived on the earth, great bodies of water called bays covered most of North America. The climate was hot and damp. The air was filled with water vapor, and it was warm the year round, even near the north pole.

At various times the sea level dropped a few feet, and then large swamps developed. Because the air was so warm and damp, the plants in these great swamps grew very fast and very tall. Some of the trees looked like huge ferns, and many of them grew to be several hundred feet high.

Today we can see a swamp forest very much like those of long ago. It is the great Dismal Swamp between Virginia and North Carolina.

The picture of the Dismal Swamp will give you some idea of how a swamp forest looked many millions of years ago.

As time passed, the trees and other plant life fell into the swamps and slowly began to decay. Instead of decaying completely, they gradually turned into a dark-looking material called peat.

As the sea level rose and fell again, a new swamp would develop in the mud and sand which had covered the old swamp forest. For thousands of years this happened again and again. The plant life in a swamp forest became peat. The peat was covered with water, sand, and mud. Then a new swamp forest grew on top of the peat. Layers formed one on top of the other: first, a layer of partly decayed plant life; on top of it a layer of sand, clay, and mud; then another layer of plant life; and so on.

Gradually the layers of decayed plant life were pressed harder and harder. After a long period of time the pressure became so great that the layers of plant material were changed. Soft, or bituminous, coal was formed. At the same time the layers of sand, clay, and mud were pressed so hard that they turned into rocks called sandstone and shale.

Over many centuries parts of the earth's crust would slowly buckle up or fold over, forming mountains. Whenever layers of soft coal were folded in this way, they received a great deal more pressure. This tremendous pressure changed the soft coal into hard coal, or anthracite.

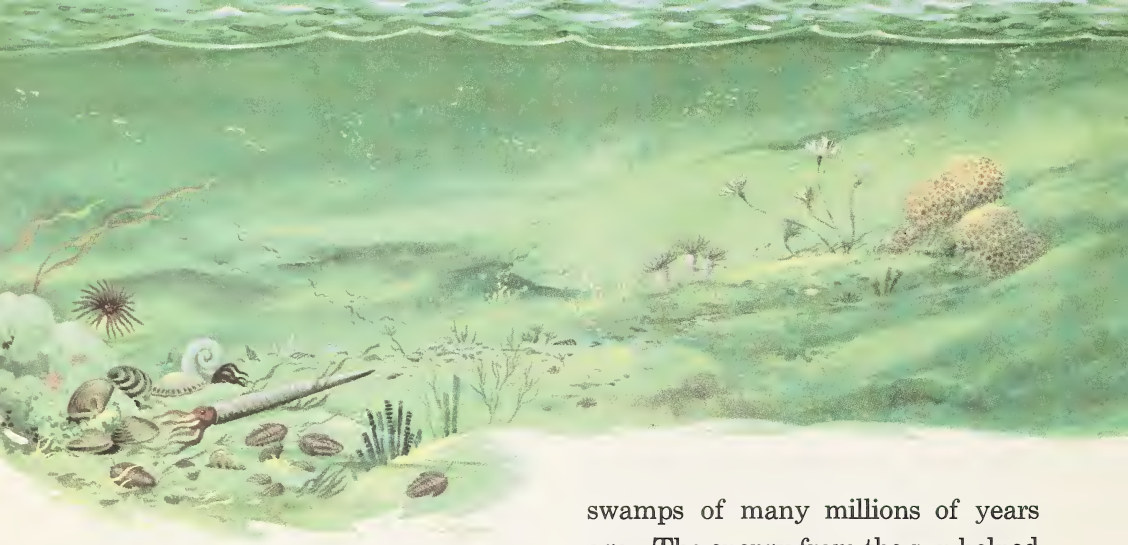
The plants which formed coal grew in the swamp forests of long ago. They needed sunlight to grow. Without the energy of the sun there would have been no coal. For this reason people sometimes say that there is "stored sunlight" in coal.

Plants of long ago made use of the sun's energy in much the same way that plants do today. Some of the energy of the sun actually becomes part of plants because plants are able to make use of light. They use light energy to produce another kind of energy. This energy of plants is called chemical energy. It is the chemical energy of plants which helps to give you health and strength when you eat the plants for food.

How important the energy of the sun shining thousands of years ago still is to us! The light energy was changed into chemical energy by those ancient plants that lived in the swamp forests. The chemical energy of the plants became a part of coal. Man has learned that he can change this chemical energy to heat energy by burning coal.

Energy from Petroleum

In another way man has benefited from the energy of the sun which reached the earth millions of years ago. He has learned to use petroleum as a fuel. We have read how the energy from the sun is used by



plants. Two of the materials which are made by plants with the use of sunlight are fats and oils. We think that petroleum comes partly from plant oils which have been buried for millions of years. We also think that petroleum comes from the bodies of tiny sea animals which lived many millions of years ago. But even the oil from the small animals depends on the energy from the sun, since animals depend on plants for their food.

Petroleum was probably formed by the remains of small animals and plants that were much like those we find in some shale and limestone today. Many of these small animals and plants lived in the seas and swamps of many millions of years ago. The energy from the sun helped the plants and animals to grow.

Billions and billions of these tiny plants and animals died and sank to the bottom of the seas, where they were covered with mud and sand. As time passed, the mud and sand gradually changed to rock. This rock was either shale or limestone or sandstone. Perhaps you can find pieces of such rocks where you live. The different kinds of plants and animals contained oil. But no one knows just how this oil formed petroleum, or crude oil.

Over the years some of the layers of the earth were gradually folded and twisted by great heat and pressure. This folding probably took millions of years. Sometimes the oil from the dead plants and animals

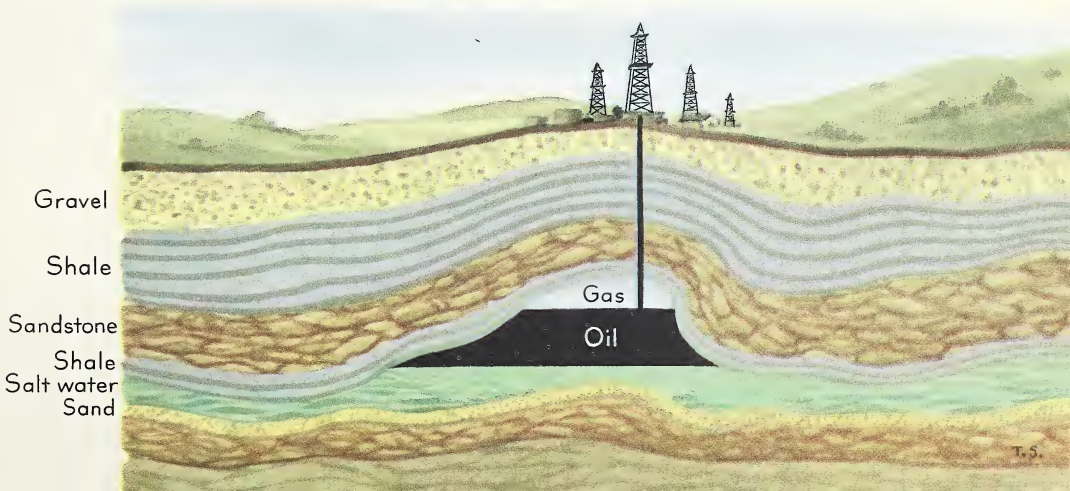
stayed in shale and made it dark and greasy. This kind of shale is called oil shale. In other cases water seeped down and mixed with the oil far below the surface of the earth. The oil floated on the water because oil is lighter than water. As the oil floated, it kept moving up. Some of the petroleum seeped up through beds of limestone or sandstone, much as water fills the pores, or tiny spaces, of a sponge. Finally, it came to a layer or a fold of rock that it could not soak through. There it became trapped.

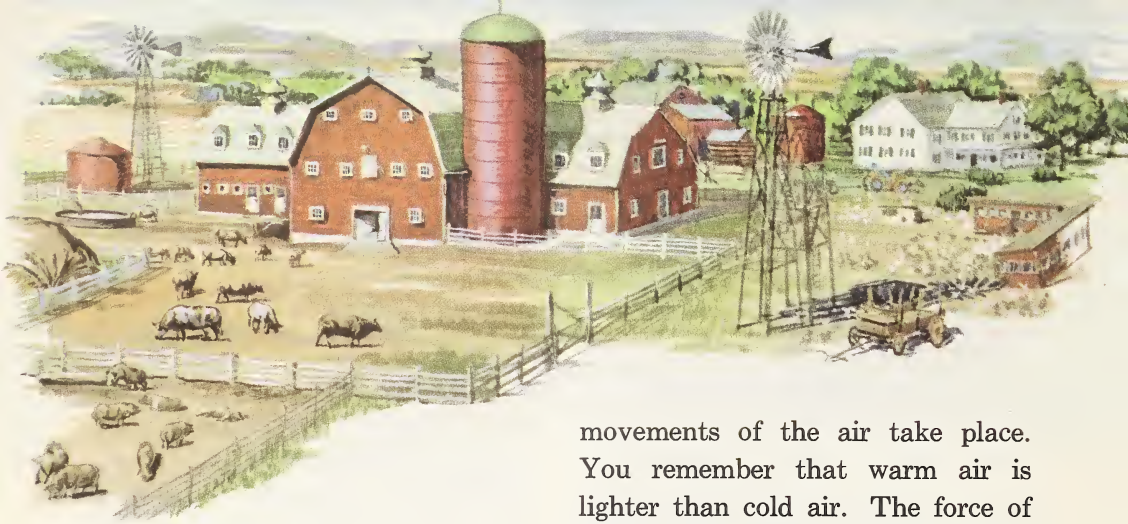
Look at the diagram on this page. Find the fold, or arch, made by the layer of rock. Sometimes petroleum is found under such a fold of rock. Such a place is called an oil trap.

Often there is a layer of shale at the top of the trap. Look at the diagram again. You can see a deposit of natural gas above the petroleum. There is much useful energy in natural gas. Below the oil there is salt water, sand, and a layer of sandstone. Petroleum seeps up through the pores of the sandstone.

Petroleum remains in one of these oil traps in the earth, under great pressure, until a well is drilled. You have probably seen pictures of oil wells that shoot gas and oil into the air. This often happens when a new well is drilled. If you live near oil wells, you may have seen a well "come in."

We have found that we can use the petroleum which comes from a well. We can separate the crude petroleum into various parts by heating it. It can be separated into gasoline, kerosene, diesel oil, and many other products. So you see, a number of other fuels have been made from the natural fuel called petroleum.





The Sun and Wind Power

Wind power is also a very useful source of mechanical energy. It was an even more important source before man learned to get energy from coal, oil, and other fuels. About one hundred years ago wind was the main source of power which drove the fast sailing vessels. These ships were used for transportation and trade. On land man harnessed the wind by means of windmills. He could then use the energy of the wind for many purposes.

Where does the energy of the wind come from? Energy from the sun heats large areas of the earth's surface. Some sections of the air become heated more than others, and movements of the air take place. You remember that warm air is lighter than cold air. The force of gravity will cause the heavier, colder air to move toward the earth. Cooler air may replace, or push out, the warmer air over a section of the earth. This movement of air is called wind. Wind is caused by gravity and the energy of the sun. It takes a lot of energy to make even a small breeze.

The people of The Netherlands have used the energy of the wind to great advantage. They have used it to pump water from the surface of the land. Much of the land that is being used in The Netherlands was once under the sea.

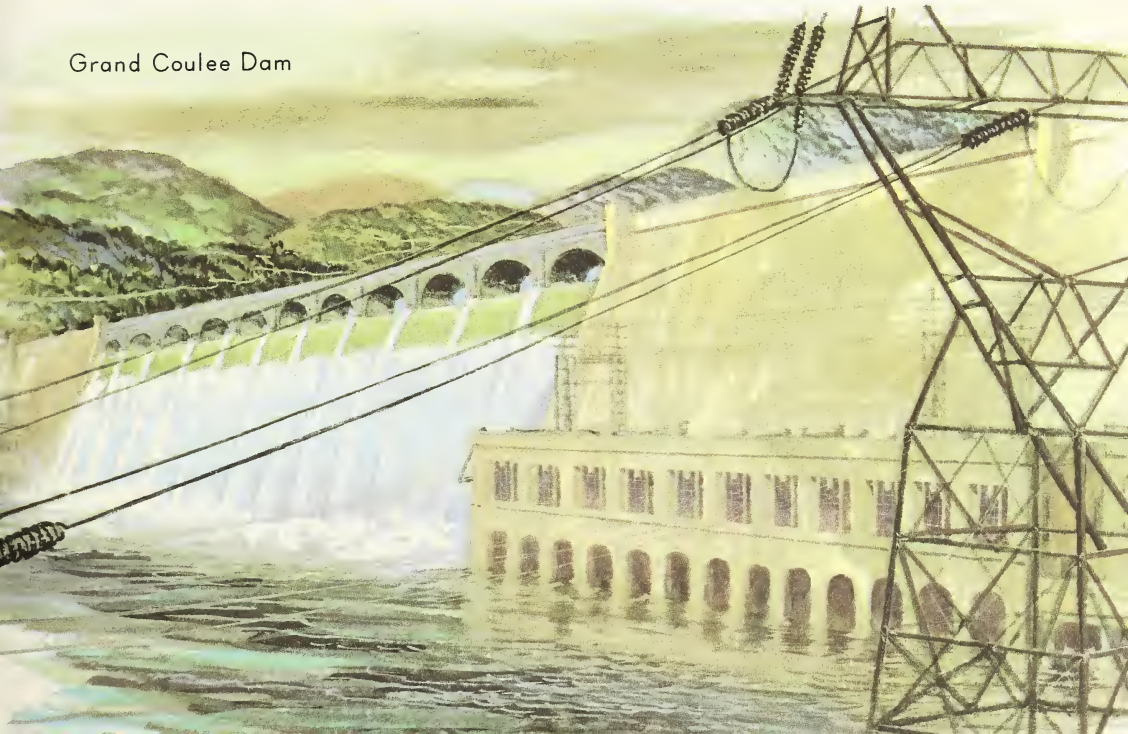
In some western parts of the United States and Canada wind power is used to produce electricity. The wind blows almost continually in these sections. Windmills can be

used to run electric generators on farms in these regions. The people who live on such farms will then have electricity, which they can use for many purposes.

We shall probably learn a great deal more about how to use the energy of wind power. Some experts have thought that wind power will be used much more in the future than it has been in the past. Perhaps you will see this happen in your lifetime. However, the mechanical energy we get from wind power is very unpredictable. We cannot be sure that the wind will produce enough power when we wish to use it.

The Sun and Water Power

Perhaps you have seen water rushing down a mountainside. Have you ever seen running water turn a water wheel? Man has learned how to benefit from the energy of moving water. He has constructed huge dams so that he can use this energy as he needs it. We have many such dams throughout the country. Grand Coulee Dam on the Columbia River is one of these. The energy of the falling water is changed to electrical energy by the machinery at the dam. The electricity is then supplied to homes and factories. Just think of all the electric lights and electric



Grand Coulee Dam

motors that are operated by energy that has come from water power!

You know that all the rivers and other streams finally empty their waters into the oceans. But where does all the water come from? You might say that much of the water once was part of the oceans. The sun provides the energy which takes the water from the oceans and returns it to the land.

When the energy from the sun strikes a body of water, a good portion of the heat energy may reach a depth of about 25 feet. As the energy is absorbed, the water is heated, and some of it evaporates. When liquid water evaporates, it becomes gaseous water. Gaseous water is called water vapor. The water vapor mixes with the other gases of the air near the surface of the water.

You remember that the energy of the sun causes the movements of the air that we call wind. As the air moves from place to place, the evaporated water which is mixed with the gases of the air is carried from place to place also. Perhaps large sections of the atmosphere begin to cool. As the particles of water vapor in the atmosphere begin to cool, they lose heat energy and change back to liquid water.

The change from gaseous water to liquid water is called condensation. When water vapor condenses, the force of gravity causes the liquid water to fall to the surface of the earth as rain. If the rain falls in a

mountainous region, the force of gravity will carry it rushing downhill toward sea level. So you see, a combination of gravity and energy from the sun provides the energy of falling water.

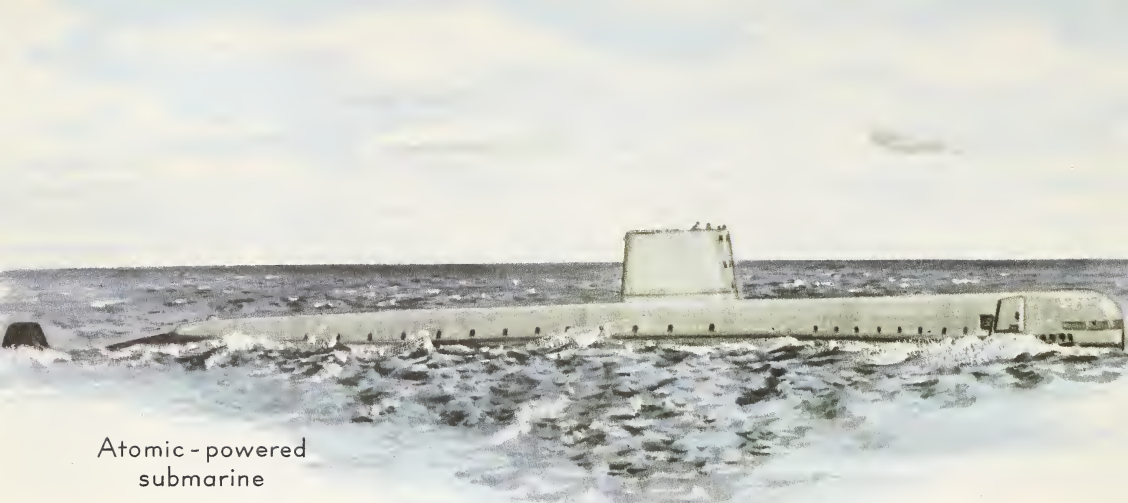
Atomic Energy

We have said that the fuels which supply the energy of the sun are really atoms. So the energy of the sun is really atomic energy. Atomic energy is probably the main source of energy for the universe.

Men who have studied the atom have known for a long time that there are vast quantities of energy inside the atom. They found that these vast amounts of energy could be released. But the problem has been to release the energy so that it could be used when needed to run machinery.

Everyone has heard about the great danger of atomic bombs. However, plans are constantly being developed to use atomic energy for other purposes. It can be used as a source of power for moving ships, for supplying energy to factories, and for many other developments. We are living in a period of very great discoveries. Perhaps you have read in your local newspaper about some of these discoveries.

Remember that man has been using atomic energy from the sun for centuries. The earth has been



Atomic-powered submarine

bathed with atomic energy for millions of years. When you take a sun bath, you are actually being bathed with atomic energy. Man is not able to go up to the sun and control the way in which its fuel is used. But we can do something about atomic fuels here on earth. Atomic fuels present a great challenge. We must learn how to release the energy of the atoms so that it can be used whenever and however we want to use it.

Uranium is one fuel which atomic scientists are using. Uranium is secured from certain rocks and minerals. It is mined from the earth. We have had to learn to use this fuel in a special way in order to produce atomic energy. In fact, we are only just beginning to learn how to use it.

Man Learns to Use Fuel

Man has gradually learned that to release energy, some sort of fuel must be used. To produce heat, man first learned how to burn wood as a fuel. This was a very great discovery which was used in many ways. The energy was used to keep homes warm and to cook food.

Man has learned to use other substances as fuels to produce heat,

light, and mechanical energy. Petroleum has been used only a very short time. Gasoline has to be used in a very special way. Man has invented a special engine to use gasoline as fuel. He uses this engine to run automobiles.

We have also learned much about other kinds of fuels. We have learned to use zinc in a dry cell as a fuel to produce electrical energy. The food which we eat is really fuel that provides muscle energy for our bodies. We are still learning to use fuels to produce energy. Some have been on our earth a long, long time, but we are only starting to use them. Others may be created by man from raw materials here on earth. You probably will use many new and different fuels which are not yet discovered.

LEARNING MORE ABOUT ENERGY

1. Electricity is used in many different ways. How many things can you name for which electricity can be used?

2. Man has learned to use the muscle energy of animals such as the llama, horse, elephant, ox, and dog. Write a story showing how the use of such energy changed the life of early man.

3. There are many different kinds of fuels. Make a list of all the fuels of which you can think. In what way must each fuel be used in order to release energy from it?

4. There may be many manufacturing plants in your community which make energy available for the community. A gas plant, a dam, and an oil refinery are really manufacturing plants which produce energy for the community's use. What are the big sources of energy for the community in which you live?

5. Modern transportation depends on energy which is released from fuels. How have the methods of transportation changed as man has learned to use the energy of fuels?

6. Man is learning to use the energy from the sun in new ways. One of these ways is that of heating homes. There are probably other ways of using the energy from the sun which will be discovered in the future. Your class might like to have a discussion about various new ways of using the sun's energy.

Why the Seasons Change

September All over the World

What is September like where you live? Are the leaves beginning to change color? Is there a crispness in the morning air?

In some parts of North America September is much as it is in the area around Omaha, Nebraska. If you were to visit Omaha during September, these are some of the changes you might see: The leaves are turning from dark greens to golden yellows, deep oranges, and brilliant reds. Many of the brightly colored flowers in the parks are fading. The air is becoming cooler. September is the beginning of autumn in the Northern Hemisphere in parts of North America, Europe, and Asia.

In many parts of the earth September is not as it is in Omaha. Look at a map of the world. Very near the equator, in Brazil, you will find the city of Belém. September in Belém is quite different from September in Omaha. In Belém the leaves are green the year round. September there is much like every other month of the

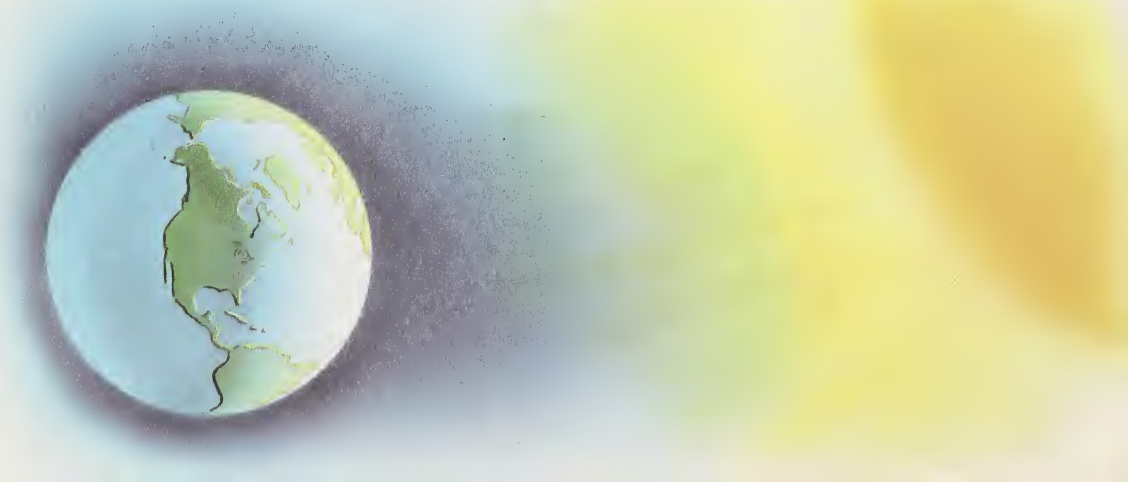
year. Along the Amazon River, in Brazil, rubber trees and coconut and Brazil-nut trees grow. No one ever needs to wear heavy clothes to keep warm. It is never cold in Belém, and it never snows.

September in some other parts of the world is quite different. In the Southern Hemisphere, in a place such as Buenos Aires, Argentina, September is the beginning of spring. The buds of forsythia are bursting into yellow blossoms. Tiny, bright-green leaves appear on the trees. The days become warmer. People are starting to plant their gardens.

In Omaha September is the beginning of autumn and in Buenos Aires September is the first month of spring. During springtime there is a gradual warming up as the summer season approaches. But during autumn there is a gradual cooling off as the winter season draws near. Develop some of your own ideas to explain why the Southern Hemisphere warms up during the same months of the year that the Northern Hemisphere cools off. Why do you think it is spring in Buenos Aires at the same time that it is autumn in Omaha?

How Sunlight Strikes the Earth

The sun is always shining on the earth. When it isn't shining on the portion of the earth which is having night, it is shining on the side of the earth which is having day. You know, of course, that our sun is a



star. The earth would be a cold, dark, lifeless place without a star nearby to provide both light and heat energy.

Throughout each year, from day to day, the earth receives about the same amount of heat energy from the sun. If this is true, how can some parts of the earth be having their coldest months of the year at the same time that other parts are enjoying their warmest months? Let's see what happens to the sun's energy when it reaches the surface of the earth.

Light Heats the Earth's Surface

Perhaps you have had the experience of sitting in the shade on a warm day. As the earth turned, you found yourself no longer in the shade. The sunlight may have first touched one of your arms or legs, and you could feel its heat. Perhaps you became so warm that you were forced to move back into the shade again.

If there is sunlight coming in your classroom window, you might try this: Stand near the edge of the lighted area and shut your eyes. Hold out one of your arms toward the sunlight. Then with your other hand mark the spot on your hand or arm where you think that the sunlight ends.

Now open your eyes and see how accurately you have been able to judge the area of sunlight. This may help you to see that light energy from the sun changes to heat

energy when it strikes the surface of the earth. You can feel the heat which the light has produced on your arm.

Perhaps you think that you feel heat from sunlight only because the sun itself is so hot. It may seem to you that the sun is like a giant furnace throwing out so much heat that some of it reaches our earth. You may think that the air gets hotter and hotter, the nearer you get to the sun.

Recently when a commercial airliner was flying over Norfolk, Virginia, it was announced that the temperature on the ground was 70° F. But the temperature of the air outside the plane, 20,000 feet high, was only 10° F, or 10 degrees above zero. The people in the plane were 20,000 feet nearer the sun than the people on the ground, but the air was 60 degrees colder.

The explanation that scientists give is that light energy from the sun does not change to heat energy as it passes through the air. But when sunlight strikes the surface of our earth, heat energy is produced. The surface of the earth becomes warm, and this in turn warms the air that is close to it.

December in Omaha

December in Buenos Aires

We know that sunlight does not produce the same amount of heat everywhere. On a December day in Omaha when the sun is shining brightly, the air may be crisp and frosty. There is often enough ice on the ponds for you to go skating. There is not enough heat energy to melt the ice. But on this same day in Buenos Aires the temperature might rise to 80° F. You could go swimming in December in Buenos Aires. Why does sunlight produce different amounts of heat in different parts of the earth?

How Light Heats a Small Space

The size of the space which a beam of sunlight covers affects the amount of heat energy received. You might try an experiment which will help to show you whether this is true. You will need a magnifying glass, an outdoor thermometer, a large piece of cardboard, and a pair of scissors. You will also need sunlight for this experiment. If none shines through your classroom windows on sunny days, perhaps you can go to a room where the sunlight does shine.

Cut a small hole in the piece of cardboard and place this cardboard in front of a sunny window. Now you will have a beam of sunlight coming through the hole. Hold the cardboard so that the beam of light falls on a table.

Have someone place an outdoor thermometer so that its bulb is in the spot of light on the table. Notice that the liquid in the thermometer rises. Record the temperature for a spot of sunlight of this size.

Now hold a magnifying glass in front of the beam of sunlight coming through the hole in the cardboard. Do you see how much smaller this makes the spot of light on the table? The same amount of light is coming through the hole in the cardboard, but the light covers a smaller space than it did before.

Shine the smaller spot of light on the bulb of the thermometer. Do you see how rapidly the liquid in the thermometer rises? You should remove the magnifying glass very quickly. There is so much heat energy in the small spot of light that it is not safe to keep it shining on anything too long.

You have found that the temperature in the smaller space was a great deal higher than it was in the larger area. This does not mean that the total amount of heat energy from the sunbeam had changed. But it

does mean that when the light energy covers a smaller space than before, there is more heat energy in the smaller space.

The same thing is true of sunlight wherever it falls on the earth. When light covers a small space, the heat increases. When the same amount of light spreads out over a wide area, the heat is spread out also, and there is not as much heat energy at any one spot.

Now do you see one reason why sunlight falling on Omaha in December might produce less heat energy than the same amount of sunlight falling on Buenos Aires? Something must happen to the light at Omaha to cause it to spread out more than it does on the same day in Buenos Aires.

Light Spreads Out on Tilted Surfaces

We have done an experiment which shows us that it is possible to change the size of the space which a beam of light covers without changing the size of the sunbeam. You might try another way of doing this.

Look at the drawings on these two pages to see how you might try the next experiment. You should have a flashlight, a piece of paper rolled into a tube, and two pieces of cardboard. It would also be a good idea to have the room as dark as possible.

First, put the flashlight inside the paper tube. Have a classmate hold one piece of cardboard straight up and down, just as the boy in the drawing below is doing.

Turn on the flashlight and stand so that the open end of the tube is about 1 foot from this piece of cardboard. The flashlight will shine on the cardboard. Have someone draw a line around the lighted spot with a colored crayon.

Now have a classmate hold the second piece of cardboard tilted as the boy in the drawing on the next page is tilting his. Then shine the flashlight on the tilted piece of cardboard in the same way and at the same distance as before. Again draw around the lighted spot. Then cut out the two spots that were outlined with crayon. Place one on top of the other. Are they the same size? Does the spot made by the beam of light on the tilted cardboard cover more space?

In both parts of the experiment the same amount of light energy

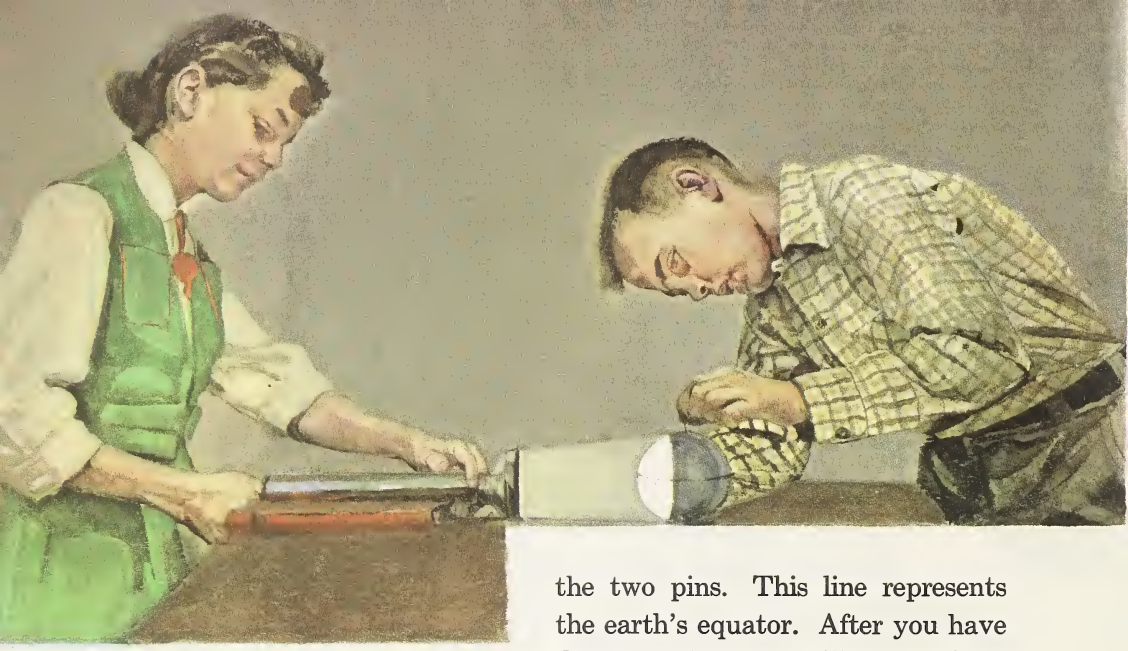
strikes the cardboard. But when the light strikes the tilted cardboard, it spreads out and covers more space. Sunlight too spreads out when the surface which it strikes is tilted.

Now we have three clues to tell us why the earth has seasons. We have learned that sunlight is changed to heat energy when it strikes the surface of the earth. We have also found that the amount of surface a sunbeam spreads over affects the temperature. Finally, we have found that the amount of surface that is lighted and heated changes as the surface tilts.

Our Tilted Earth

We have said that it might be cold enough to go skating on a sunny December day in Omaha. Perhaps you could go swimming on this same day if you lived in Buenos Aires.

In December the sunlight produces less heat energy in Omaha than it does in Buenos Aires. The tilt of the earth has something to do with this difference in temperature. To



understand this, we must first understand what is meant when we say that our earth is tilted.

If the Earth Did Not Tilt

First, let's see how sunlight might fall on the earth if the earth were not tilted. You can use a tennis ball to represent the earth. Push a pin part way into the tennis ball. It should be in firmly enough for you to lift the ball by holding the pin. Then insert another pin lightly on the other side of the ball exactly opposite the first. With a pencil or a crayon draw a line on the ball all the way around it, halfway between the two pins. This line represents the earth's equator. After you have drawn the line, you will not need the second pin and you can remove it.

Now you are going to shine a flashlight, representing the sun, on the ball. It would be a good idea to put the ball on a piece of paper on a table and mark the spot where it rests, so that you will be able to put it in this same place again later on.

Hold the ball up by the remaining pin so that the ball is just lightly touching the paper. Have a classmate arrange a flashlight on books on the table at the right height and distance so that the light will shine most brightly on the ball at the line which represents the equator. It will help if the room is darkened.

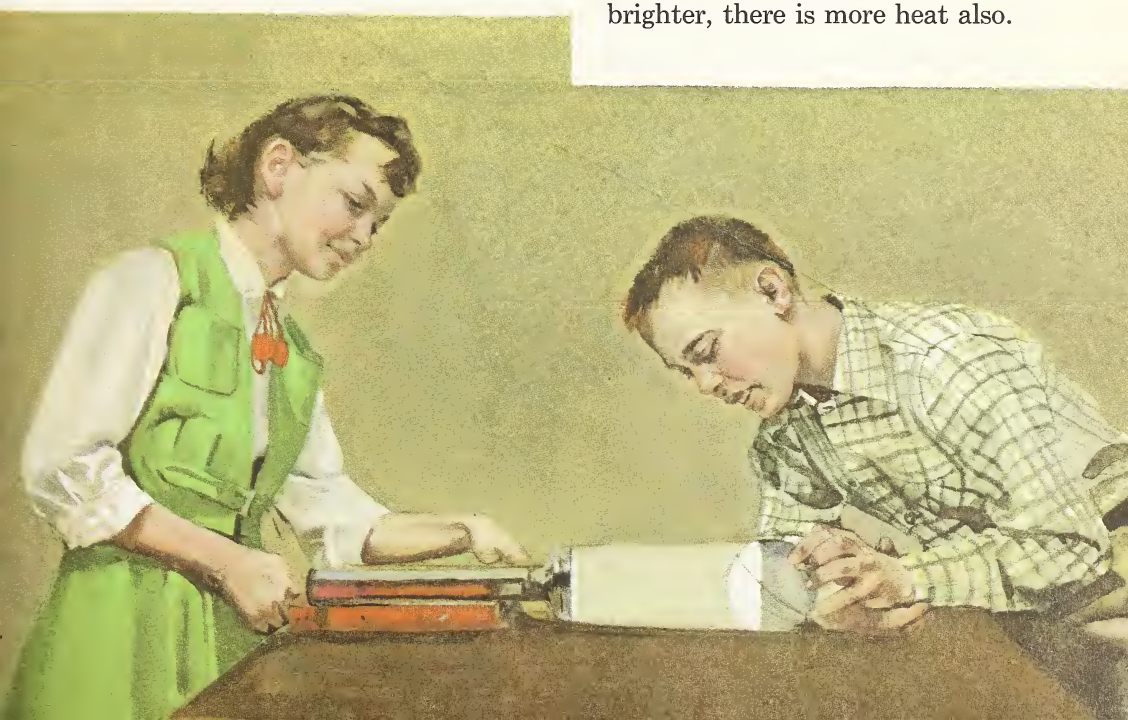
Now let's imagine that the tennis ball is really the earth and the flashlight is the sun. Notice that the light spreads out about equally above and below the equator. If this were the way that sunlight fell upon the earth, what could you say about the seasons?

The areas north and south of the equator would receive the same amount of energy from the sun the year round. December in Omaha would not be very different from December in Buenos Aires. But we know that this is not the case. Let's see what happens when we experiment with a tilted ball.

Our Earth Is Tilted

Still holding the ball by the pin that was inserted, rest the ball on a table. Again shine the flashlight on the line representing the equator, but this time tilt the ball away from the light. The picture on this page will show you how much to tilt it.

Do you see that there is now less light above the equator than before? The amount of light energy shining on the ball has not changed. But now the light is brighter below the equator than above it. What season would this represent in the Southern Hemisphere? Would it be warm or cool north of the equator? Remember that wherever the light is brighter, there is more heat also.



We know that at times on our earth areas north of the equator may be covered with ice and snow while fields are green in the Southern Hemisphere. At other times the opposite is true. In June the air is cool and wintry in Argentina, and the children wear warm clothes to school. In the Northern Hemisphere summer vacation is beginning in June.

The seasons are different as different parts of the earth change their positions in relation to the sun. This happens because our earth is tilted.

The Earth Moves about the Sun

You know, of course, that the earth is a planet revolving about the sun. You know, too, that the earth is rotating, or spinning, as it moves about the sun. It takes the earth one day, or about 24 hours, to spin around once. To make one complete journey about the sun takes our spinning earth one year, or about $365\frac{1}{4}$ days. Another way to say this is that the earth rotates $365\frac{1}{4}$ times while it revolves about the sun once.

As the earth spins around, day follows night, but the number of hours of daylight are not always the same on all parts of the earth. Can you remember summer evenings when the sun did not set until long after suppertime? Now think of the wintertime. Does the daylight begin

to fade on winter days even before you have had supper?

We think that the number of hours of daylight each day has some effect on temperatures. When the days are long, there are more hours for the surface of the earth to be warmed by the sunlight. There is less time at night for that part of the earth to cool. Winter days are short, and summer days are long. This is true in Omaha and it is true in Buenos Aires. Don't forget, however, that Omaha is having winter at the very same time that it is summer in Buenos Aires. This means that the same day can be long in one place while it is short in another.

Something You Can Do

This is something you can do which will help you to understand how the earth moves around the sun: You will need an electric light, some clay, cardboard, and toothpicks. You will also need a globe somewhat like the one in the picture above.

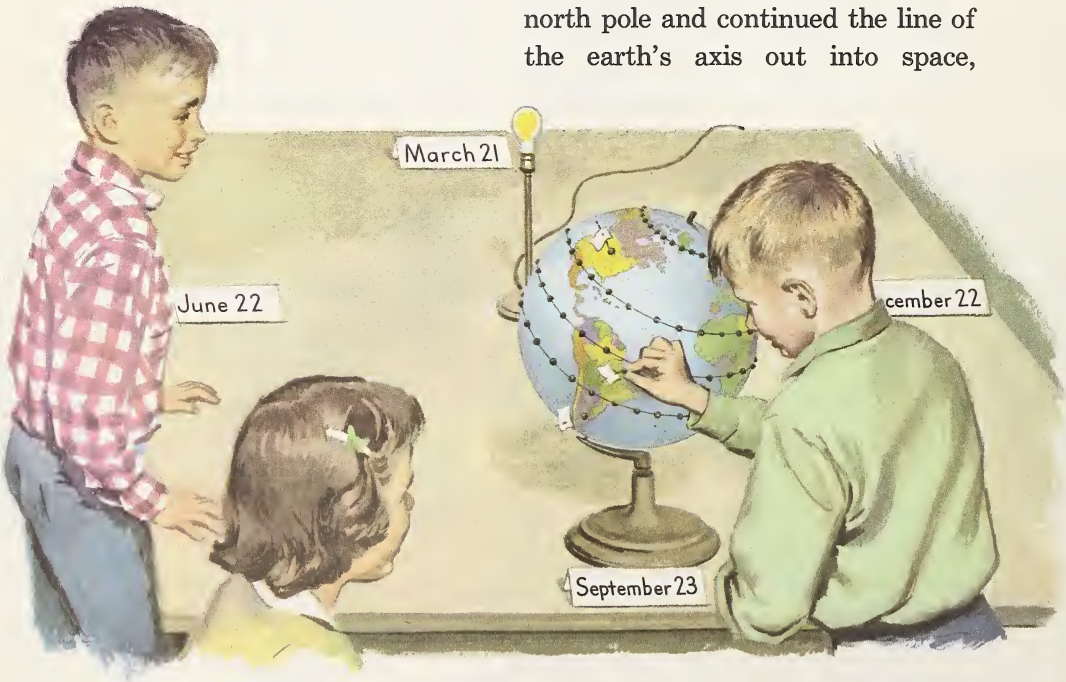
First, form the clay into tiny balls. Each ball should be only about $\frac{1}{8}$ inch in diameter. You are going to need a great many of these small clay balls to fasten on the globe. Place 24 of the tiny balls on the globe around the Arctic Circle. Space them equal distances apart. Then place another set of 24 balls around the Tropic of Cancer. These balls will be farther apart than

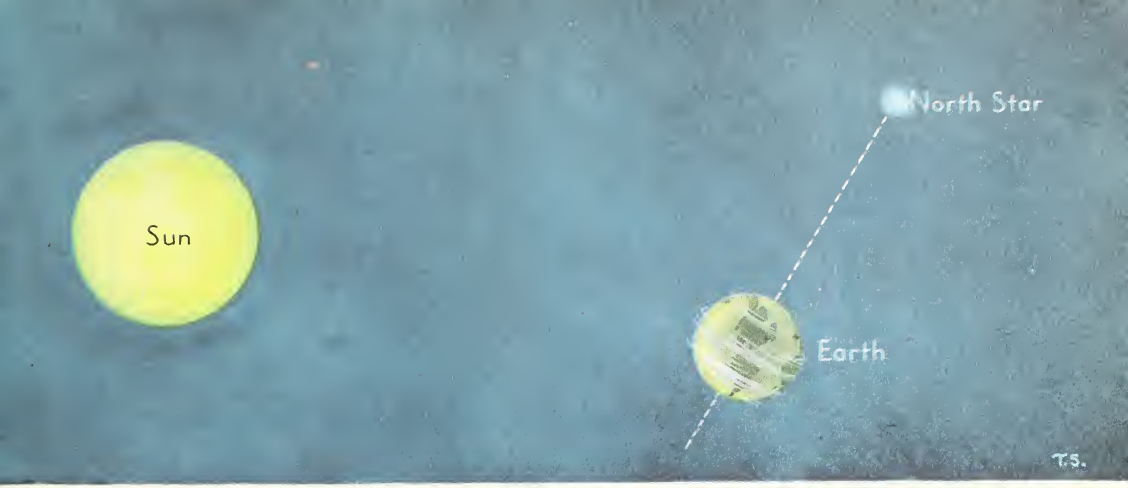
those around the Arctic Circle, but they should be at equal distances from each other. In the same way fasten other sets of 24 balls to the globe around the equator, the Tropic of Capricorn, and the Antarctic Circle.

You might place three markers on the globe to show the correct locations of Omaha, Belém, and Buenos Aires. You can make the markers by cutting out three small paper flags. If you put one end of a toothpick through each paper flag and the other end in a small ball of clay, the clay will hold each marker in place on the globe.

Now make four labels out of cardboard. The labels should read: December 22, March 21, June 22, September 23. Put an electric light in the center of a table. The light will represent the sun. Arrange the labels around the light just as you see them in the picture below. Now place your globe in the September position. Look at the picture again. Do you see the direction in which the globe is tilted?

You probably know that the north pole and the south pole of the earth are opposite ends of an imaginary line called the earth's axis. As the earth spins, it turns about this imaginary line. If you started at the north pole and continued the line of the earth's axis out into space,





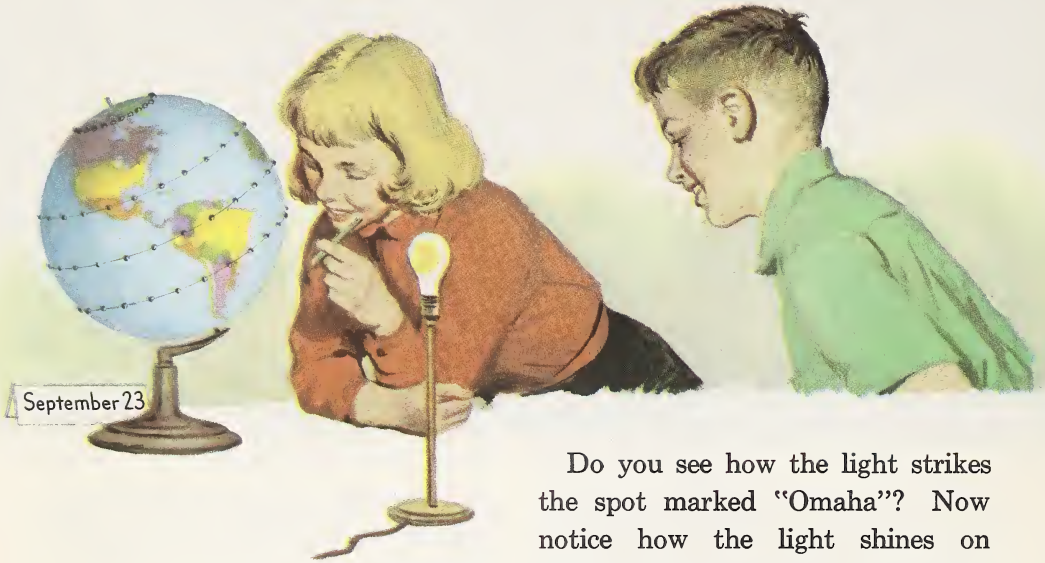
it would point toward the North Star, or polestar. All year long, as the earth journeys about the sun, the line of the earth's axis tilts toward the North Star.

When you have correctly placed your globe in the September position, the axis of your globe will be pointing toward an imaginary North Star. Wherever you move the globe about the light which represents the sun, its axis should continue to point in this same direction.

Now darken the room and turn on the light on the table. Check to see whether half the clay balls on the globe are lighted. You may need to raise the light by placing it on some books so that it will be on a level with the equator of the globe. If the balls have been correctly placed, and the light is at the right height, about sixty of the balls will be lighted at one time.

You know that as the sun shines on the earth, half the earth is always having day. All year long, part of the earth is turned toward the sun, and part is in the shadow we call night. Half the earth is always lighted, but the lighted half is constantly changing. You might try turning your globe part way round on its axis and again counting the number of lighted balls. Does the number stay the same?

Now you are ready to learn more about the movement of the earth around the sun. This demonstration will help you to understand how sunlight falls on the earth throughout the year.



September 23 Everywhere

On September 23 sunlight strikes the earth in much the same way that the electric light shines on the globe in your demonstration. Notice how brightly the equator is lighted. Does the light spread out equally north and south of the equator?

Look at the north pole and the south pole. Both these places are getting light from the sun. On September 23 there is light from pole to pole.

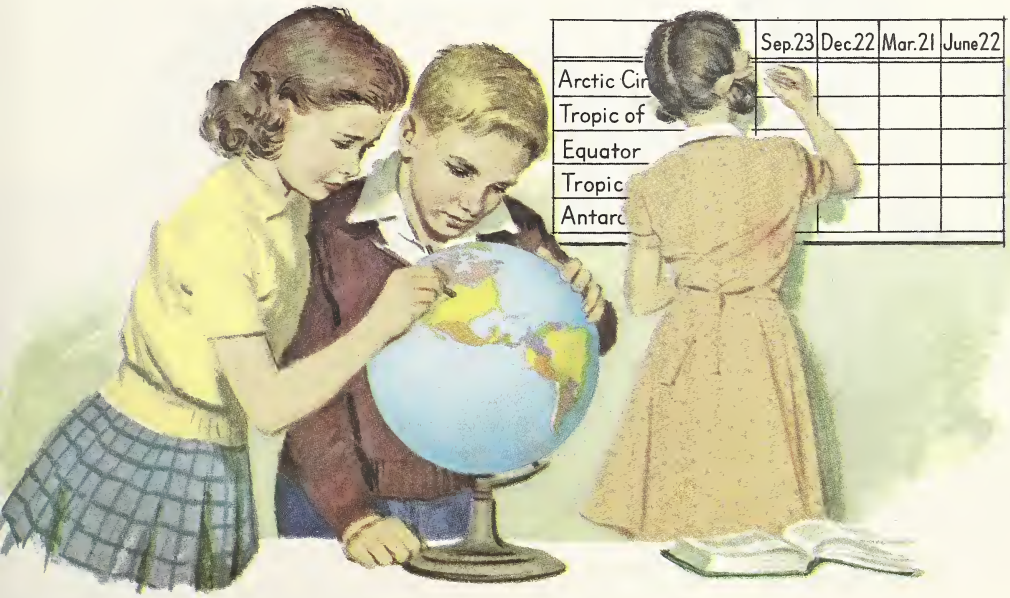
At Belém it is very warm, but the temperature is lower at the poles. The light spreads out more there than at the equator.

Do you see how the light strikes the spot marked "Omaha"? Now notice how the light shines on Buenos Aires. You can see from your demonstration that both places receive almost the same amount of light in September. The light and heat energy spread out a bit more in Omaha than in Buenos Aires because Omaha is a little farther away from the equator. The amounts of light that the two places receive are so similar that it might make you think that the season would be the same in both. The days are quite warm and sunny in Omaha, as well as in Buenos Aires. In Omaha, however, September is the beginning of autumn, and winter will soon be on the way. In Argentina September is the beginning of spring, and the warm days of summer lie ahead.

But there is one thing which is the same on September 23 at all three spots which you have marked on your globe. Belém and Omaha and Buenos Aires have the same number of hours of daylight and of night. In fact, on this date the hours of daylight and of darkness are about of equal number everywhere on the earth.

You can check the number of hours of sunlight in the day on September 23 by counting the number of clay balls that are lighted in each set on your globe. You know that there are 24 hours in a day, and there are 24 clay balls in each set. The number of balls lighted in each set will be about the same as the number of hours of sunlight in the day in each region.

It will help you to compare September 23 in different parts of the earth with other times in the year if you record your observations on a chart. Look at the illustration below to see how your chart might be made. You might even make one large enough to hang on the wall. At the side of the chart you will want to list the locations of the earth that you are observing: Arctic Circle, Tropic of Cancer, Equator, Tropic of Capricorn, and Antarctic Circle. Across the top of the chart you will need these dates: September 23, December 22, March 21, June 22.



Count the number of lighted balls in each of the five different locations on the globe. Record each number on the chart below the September 23 heading. How do the five numbers compare with each other? Do you see that they are about the same for all five regions of the globe? About half the balls in each set are lighted. This shows you that days and nights are of about equal length all over the globe on September 23.

How the Earth Moves

As the earth moves onward in its journey around the sun, some parts of the earth receive different amounts of heat energy than they did in September. Also, days and nights do not continue to be of equal length. Your demonstration will help you to see how this happens.

Move your globe to the December position. Be sure to keep it tilted in the same direction as before. Notice the way that the light now shines on the globe. Do you see that although you have not changed the tilt of the globe, the tilts of the Northern and Southern Hemispheres have changed? In September neither pole tilts toward the sun, but in December this is not so.

Look at the Southern Hemisphere. How brightly the light shines on this part of the globe! On the earth

south of the equator spring has given way to summer. Around Buenos Aires the crops are ripening in the fields. The days have become so warm that it is pleasant to sit in the shade or to go for a cool swim.

See how the light shines on the globe at the south pole. Are all the clay balls around the Antarctic Circle lighted? How many hours of daylight does this mean that there would be here on December 22?

Now notice how the light shines on the equator. This region still seems to be as brightly lighted in December as it was in September. There day and night are still about equal. The season has not changed.

North of the equator, in the Northern Hemisphere, you will find a different story. This hemisphere tilts away from the sun in December. The light spreads out more. This means that the sunlight does not produce as much heat energy here. The days are becoming cold and wintry. In Omaha there may be snow on the ground. There are no leaves on most of the trees. The children wear heavy clothing in order

to keep warm. There in December autumn is over, and winter has begun.

Look again at your globe and, as before, count the number of clay balls that are lighted in each of the five sets. Record the numbers in their proper places on your chart and compare them with your previous figures. You will probably find that none of the clay balls around the Arctic Circle are lighted on December 22. If you lived in these regions, you would not see the sun at all on this date. It would be so dark that it would be like night all through the day.

How many balls in all do you see lighted? Do you find that the light is still shining on about half of all the balls on the globe? The amount of sunlight shining on the earth has not changed in December. But different parts of the earth now receive different amounts of light and heat energy from what they received before.

Because the earth is tilted, there are more hours of daylight south of the equator in December than there are in September. At the same time there are more hours of night and fewer hours of day in the Northern Hemisphere. Because of the earth's

December 22 in the antarctic regions

tilt also the sunlight in December spreads out more above the equator than below. As the sunlight spreads out, it produces less heat energy. Does this help you to see how there can be short, cold, winter days in Omaha at the very same time that people in Buenos Aires are enjoying the long, warm days of summer?

Still keeping your globe tilted in the same direction, move it to the March position. Again observe how the light falls on different parts of the globe. Count the number of clay balls that are lighted and enter the figures on your chart.

You will find that days and nights are about equal everywhere on the globe in March, as they were in September. In March also neither hemisphere is tilted more than the other toward the sun. Places north of the equator receive about as much light and heat energy in March as those the same distance south of the equator. But again the seasons are different.

You remember that December was a time of higher temperatures in the Southern Hemisphere and of lower temperatures in the Northern. As the months change from December

to March, the temperatures rise in the Northern Hemisphere while they are dropping south of the equator. Even though in March the temperatures of both hemispheres are becoming somewhat the same, the seasons are different. This is because the weather in one hemisphere is moving from a period of warmth to a cooler time while just the opposite is happening in the other hemisphere.

Move your globe to the June position and again notice how the light energy concentrates in some parts of the globe and spreads out in others. Count the number of clay balls lighted in each place. What would the seasons now be in Omaha and Buenos Aires?

The Seasons Change

We have seen that as day follows day throughout the year, the seasons in the Northern and Southern Hemispheres are different. While it is autumn in one hemisphere, it is spring in the other. This is true of summer and winter also. Yet at the equator at sea level the temperature hardly varies at all from month to month. Here there is no summer nor winter, spring nor fall.

Do you see now how all this is possible? You remember that the north pole of our earth is always tilted toward the North Star. As the earth travels about the sun, however, sunlight strikes our tilted earth in varying ways. At the equator there is

hardly any change. The amount of heat energy from the sun varies when the light spreads out in the Northern and Southern Hemispheres. The numbers of hours of daylight vary also. The seasons change as first one pole and then the other is tilted toward the sun. Autumn, winter, spring, and summer—one season follows another because the earth is tilted as it makes its yearly trip around the sun.

LEARNING MORE ABOUT SEASONS

1. How does seasonal change affect what we do? You might list some activities that are affected by seasonal change.

2. Have one of your friends measure your shadow at nine o'clock in the morning, at twelve o'clock noon, and at three o'clock in the afternoon. Observe the size of your shadow. When is it the longest? When is it the shortest? Where does the sun seem to be for each of the shadows you made?

After a month repeat the making of your shadow. Your shadow should be measured at the same times during the day as before. Do you observe a difference in the length of your shadow? What makes the difference? During which season would your shadow be the longest? the shortest?

3. To find out that the hours of sunlight change from one day to another, you can do this: keep a record of the time the sun rises and sets each day. If the sun rises before you get up in the morning, you can probably get this information from a newspaper, radio broadcast, or television program.

Why are the hours of sunlight less each day in autumn in North America? Why do the hours of sunlight increase here each day during spring?

4. Explain why the sun seems to rise in the east and seems to set in the west each day.

5. Choose a city in Europe and a city in Australia and make a chart showing what seasons each would be having during March, June, September, and December.

6. Observe where the sun rises and sets in the sky one day each week for several months. Does the position of the sun in the sky seem to have changed? Why?

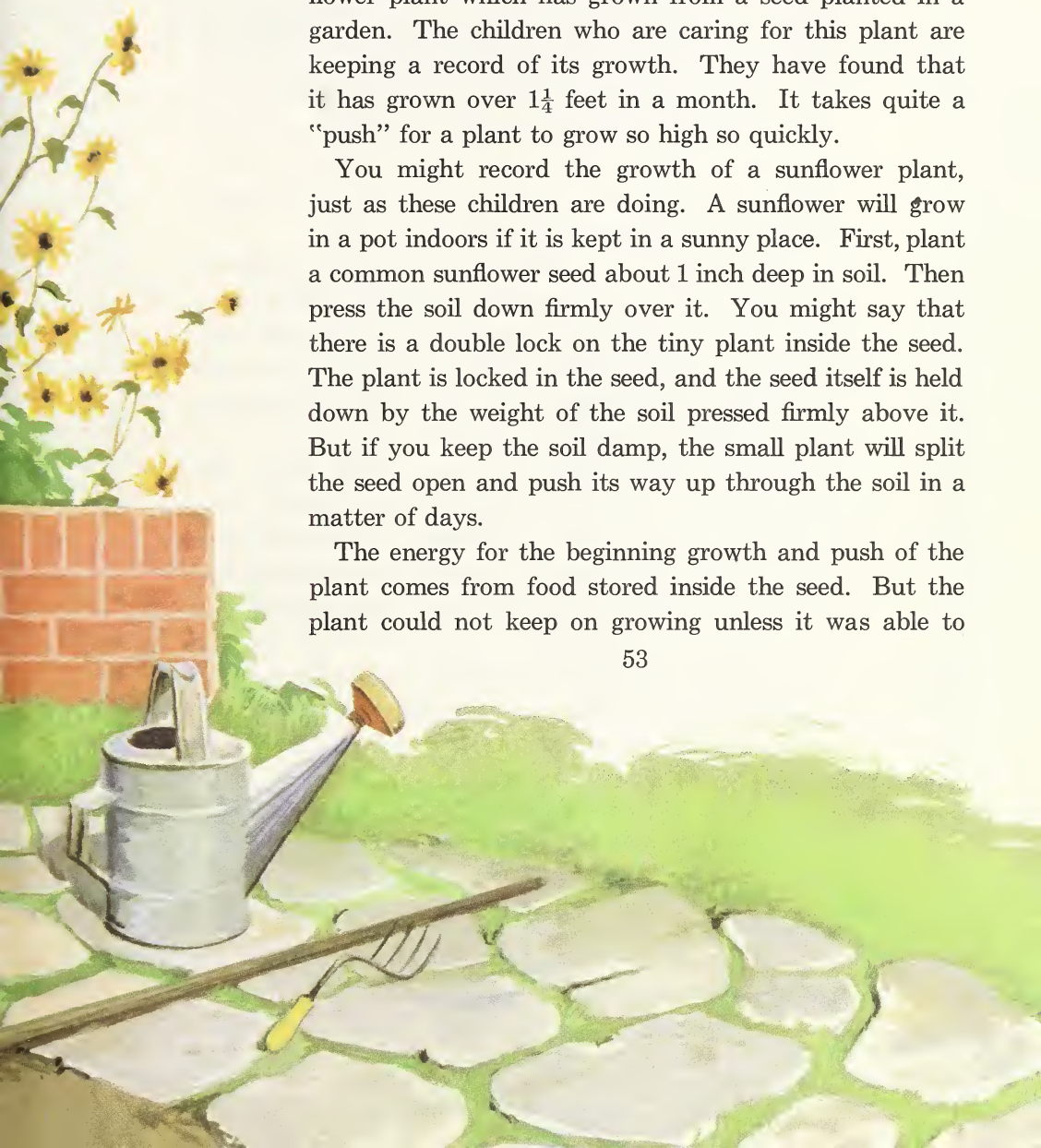
Energy and Plant Growth

Plants and Sources of Energy

Did you ever think that there is quite a bit of energy locked in a tiny seed? In the picture you can see a sunflower plant which has grown from a seed planted in a garden. The children who are caring for this plant are keeping a record of its growth. They have found that it has grown over $1\frac{1}{4}$ feet in a month. It takes quite a "push" for a plant to grow so high so quickly.

You might record the growth of a sunflower plant, just as these children are doing. A sunflower will grow in a pot indoors if it is kept in a sunny place. First, plant a common sunflower seed about 1 inch deep in soil. Then press the soil down firmly over it. You might say that there is a double lock on the tiny plant inside the seed. The plant is locked in the seed, and the seed itself is held down by the weight of the soil pressed firmly above it. But if you keep the soil damp, the small plant will split the seed open and push its way up through the soil in a matter of days.

The energy for the beginning growth and push of the plant comes from food stored inside the seed. But the plant could not keep on growing unless it was able to



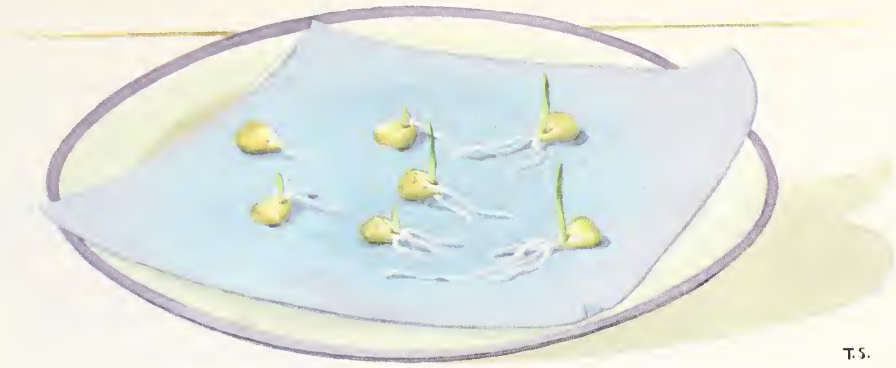
manufacture more food. This is used by the plant to supply chemical energy for further growth.

In order to manufacture food, the plant must have a source of energy outside itself. This energy is supplied by the sun. If the right conditions prevail, the plant inside a sunflower seed may supply itself with enough chemical energy to grow 10 or more feet tall.

It is interesting to observe a full-grown sunflower plant in bloom. You can see how sensitive it is to sunlight. All day long the blossom slowly turns to face the sun. As the sun sets, the sunflower will be facing west. It will face west throughout the night. But at sunrise it will swing back to the east to face the rising sun.

Like other green plants sunflowers make use of the sun's energy to manufacture food in their leaves. But light energy is not all that plants need. In fact, in most cases no light energy reaches seeds when the tiny plants inside them first begin to grow. It is dark down in the soil where seeds are planted.

What starts a plant growing from a seed? Your class might like to have a discussion about this.



Plant Growth and Water

Water is needed by plants to manufacture their food. Water does not supply the energy for plant growth directly. But without water plants would not be able to manufacture their energy supply.

More than 70 per cent of the weight of certain plants is made up of water. Seeds also contain water, although the water present in seeds may fall as low as 10 per cent or even less. The young plant in a seed will not start to grow until additional water is provided for it.

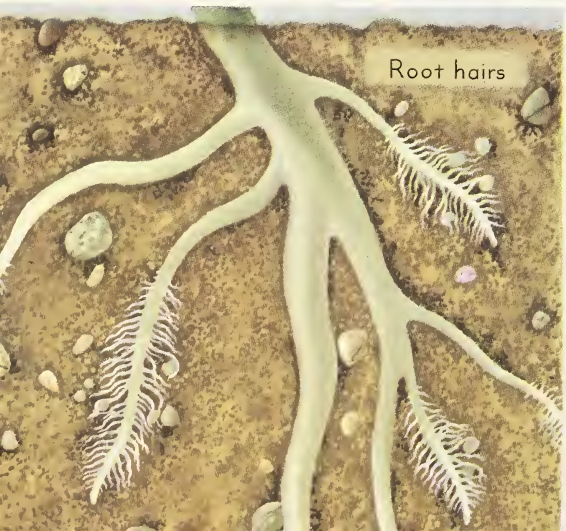
Water Enters the Plant

How is water taken in by the tiny plant inside a seed? You might try an experiment to see how seeds begin to grow. Put some kernels of corn on a piece of blotting paper in a dish. Keep the blotting paper damp and watch the seeds from day to day. Soon you will see that the kernels have split open and tiny roots have appeared. Later the rest of the plants will begin to develop.

Plants take in water through their roots. In most cases the water that plants use comes to them from the soil. Their roots extend down into the soil and draw water from it. Water is not taken in by the whole roots, however. There are certain little extensions on roots through which water enters. These are called root hairs. They are thin tubes, closed at the free end, and are capable of absorbing water through their surface. The length of root hairs varies. Some are quite small. Others may be as long as $\frac{1}{4}$ inch.

Often when a plant is dug up and replanted in another spot, the root hairs are destroyed. The plant will wilt and may die because it will not be able to take in water. But as you have probably noticed, the wilted plant may "pick up" again. This happens as new root hairs are formed. The freshly-grown root hairs allow water to enter the plant again.

Root hairs do not live very long, even on a plant which is not moved or disturbed. Each root hair works well for only a few days or weeks. Then it is no longer of any use to the plant. It shrivels and dies. But new hairs are always being formed by the plant as it grows. In this way there are enough root hairs to keep a good supply of water moving into the plant.



Some plants have roots that grow deep down into the soil. The roots of other plants are near the surface. There are examples of both kinds of roots among the many plants that grow in deserts.

Desert soil usually contains very little water. Some desert plants, such as mesquites and yuccas, have long roots, which reach down to water that may be deep underground. The roots sometimes grow to be 40 feet long. Many cacti have roots that spread out just below the surface of the soil. These plants can get water quickly when showers come.

Roots Take in Minerals

In addition to water there are other materials which enter plants through their root systems. These materials are called mineral elements. They are found in good topsoil and are necessary to plants for proper growth. Without them a plant may develop so poorly that it will die.

Scientists do not always agree which mineral elements are most needed by plants. There are seven of these elements that most scientists consider very important. These are

potassium, calcium, nitrogen, iron, sulfur, phosphorus, and magnesium. There are other minerals that may be as important in the growth of healthy plants, but plants need only very small amounts of each.

Each mineral is important to a plant in a particular way. For example, there is magnesium in chlorophyll. Chlorophyll is a chemical in the leaves of plants which they use in manufacturing food. Without magnesium a plant would have no chlorophyll and would not be able to make food. So a decrease in magnesium would mean a decrease in the amount of energy a plant has for growth.

Some of the minerals in soil dissolve in water. They are taken into plants with the water which the roots absorb. But plants take some minerals directly from soil. Their roots are able to dissolve minerals and take them in through the root surfaces.

Some children tried an experiment which helped to demonstrate that roots can dissolve mineral elements. A piece of highly polished marble was covered with about an inch of soil. Some bean seeds were planted in the soil and watered. As the bean plants developed, some of the roots came in contact with the marble.

The plants were allowed to grow for several weeks without being disturbed. Then the marble was removed and the soil washed from it. The appearance of the marble had changed. Where the roots had been in contact with it, they had left a pattern. This pattern was made as the roots dissolved the mineral elements of the marble.

The mineral elements found in soil are highly necessary to plants. But plants can be grown without soil if water and the necessary elements are supplied. This kind of agriculture is called hydroponics.

There are certain difficulties in hydroponic farming. As you know, when plants are grown in soil, the soil serves to support them. Without soil, plants must be supported in some way. Also, little green plants known as algae are apt to grow on the surface of the solution of water and minerals. Some method must be used to control the growth of these algae. One way of doing this is to cover the surface of the water so that sunlight does not strike it. Despite these difficulties hydroponics may prove to be a very useful way of producing large quantities of food in the future.

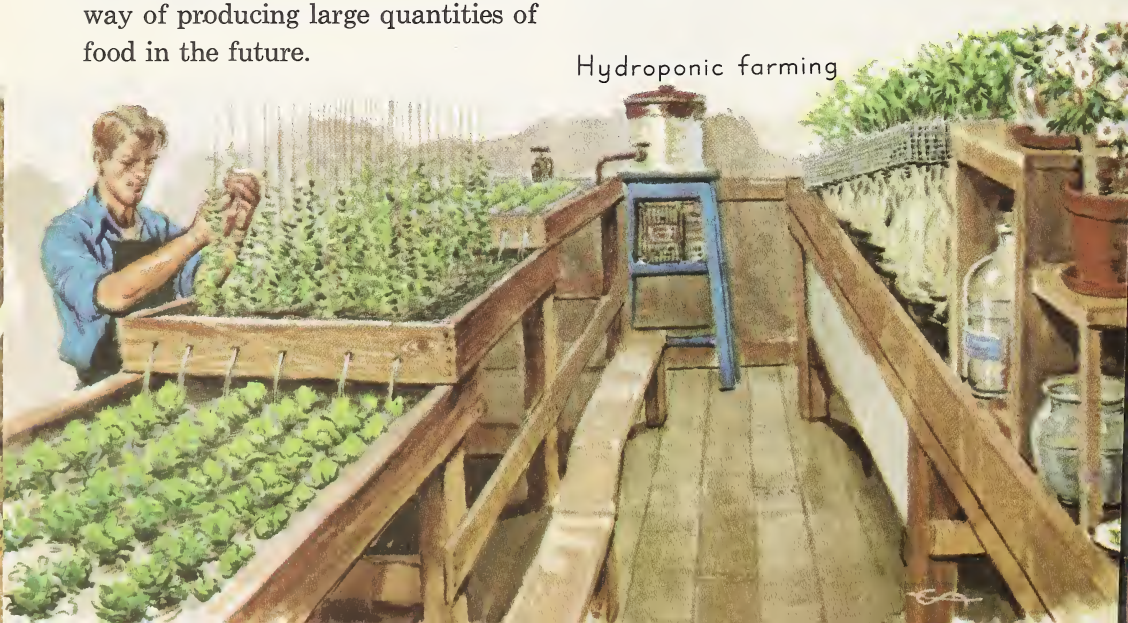
Leaves Give Off Water

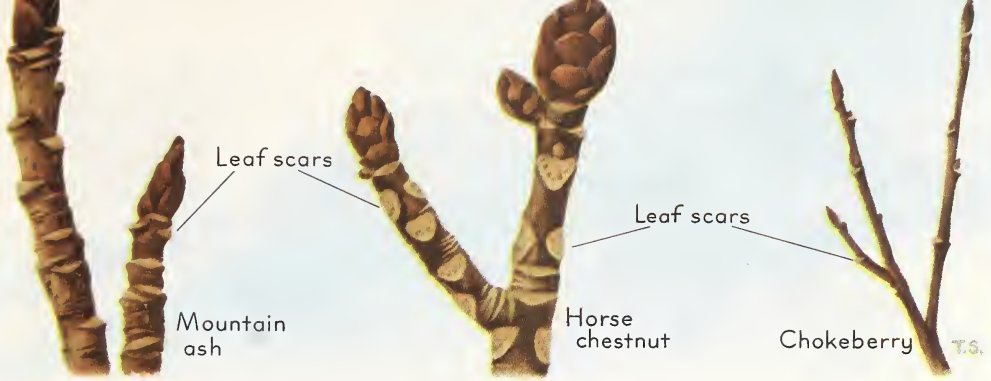
Water passes through the root hairs and moves up through the plant. You might say that there is a stream of water moving through the plant from roots to leaves. In the leaves of the plant some of the water is used in the manufacture of food. Much of the rest of the water is given off by the leaves.

In late summer or early autumn many trees lose all their leaves. These trees are called deciduous. Cottonwoods, maples, elms, and birches are deciduous trees you may have seen.

Deciduous trees give off much water through their leaves. When there is little water that trees can use in the ground, the trees may lose too much water through their leaves.

Hydroponic farming





Autumn is the season of the year when the days begin to grow shorter than the nights. There is less light and heat energy. When less of the sun's energy reaches a region of the earth, the ground grows cold, and there is less water in the soil for trees to use. Perhaps you have never thought that plants must live under desert-like conditions when the weather is very cold.

When the ground is frozen, the water in the soil is in the form of ice. Plants can use water only in its liquid form. Of course they cannot take ice up through their stems.

Have you ever looked carefully at frozen soil? If you live in a place where the ground freezes in winter, try digging up some of the frozen soil. Or stamp on the ground with your feet. Does it feel hard?

You might try freezing some soil and examining it. Put some soil in a container that will go into the freezing unit of your refrigerator. Wet the soil well and leave it in the unit for several hours. Do you see any water that plants could use?

As times of lessened heat and light energy approach, the leaves of deciduous trees are dropped. A thin separation layer grows at the base of each leafstalk. It develops between the stalk of the leaf and the branch on which the leaf is growing. As soon as the separation layer is completely formed, it cuts off the supply of water, and the leaf drops.

There is no opening where each leaf has been. A layer of tissue grows over the spot where the leaf was attached to the branch. This spot is called a leaf scar.

You might like to examine the leaf scars on some of the trees and shrubs in your schoolyard or perhaps in a park. Leaf scars are easy to see on

Leaves of deciduous trees

twigs in the autumn, but you can see them at other times of the year also.

Probably you have seen some deciduous trees in your neighborhood that have not lost all their leaves in the autumn. Certain kinds of oak trees and other plants keep some of their dead leaves most of the winter. On these plants the separation layers may not have completely formed. Sometimes the veins which go from the twigs through the stems of the leaves may not have broken. The leaves usually fall off by spring.

Leaves of evergreens

Some trees stay green as long as they live. They never lose all their leaves at once. The leaves of some evergreen trees live for three, four, or more years. Some new leaves grow each year, and each year some of the older leaves drop off. It is possible for evergreen plants to lose some of their leaves at any time during the year because the separation layers may form at any time.

The leaves of some evergreen plants fall at regular times during the year. The white pine sheds many of its two-year-old or three-year-old leaves in late autumn. But there are always some leaves left on the plant.

Many evergreen plants have needle-like leaves. These plants lose less water than do most plants with broad

leaves. A live oak is an evergreen which has quite different leaves. Its leaves may be several inches long and up to 3 inches wide. They are not at all like pine needles. These leaves stay on the tree a year or longer. Then they turn brown and fall off. New leaves have already come out. A live oak has green leaves on it all year. Live oaks do not grow where the winters are severe.

Live oak

The surface from which water can go into the air is less in desert plants than in the large leaves of trees such as maples and oaks. The outside covering of the leaves of desert plants is harder and thicker than the covering of maple and oak leaves. These things help to make it possible for plants to live where there is very little water.

A plant called an ocotillo grows in some parts of the southwestern desert of North America. This plant has produced new leaves as many as eight times a year. When no water is available, the leaves turn brown and drop off.

Many desert plants have small, stiff leaves. The leaves of the creosote bush are hard and look as though covered with shellac. The leaves of some plants look waxy; others are covered with fine, short hairs. On some plants spines take the place of leaves. Water does not evaporate quickly from leaves like these.

Creosote bush

Ocotillo

Plants Use Energy

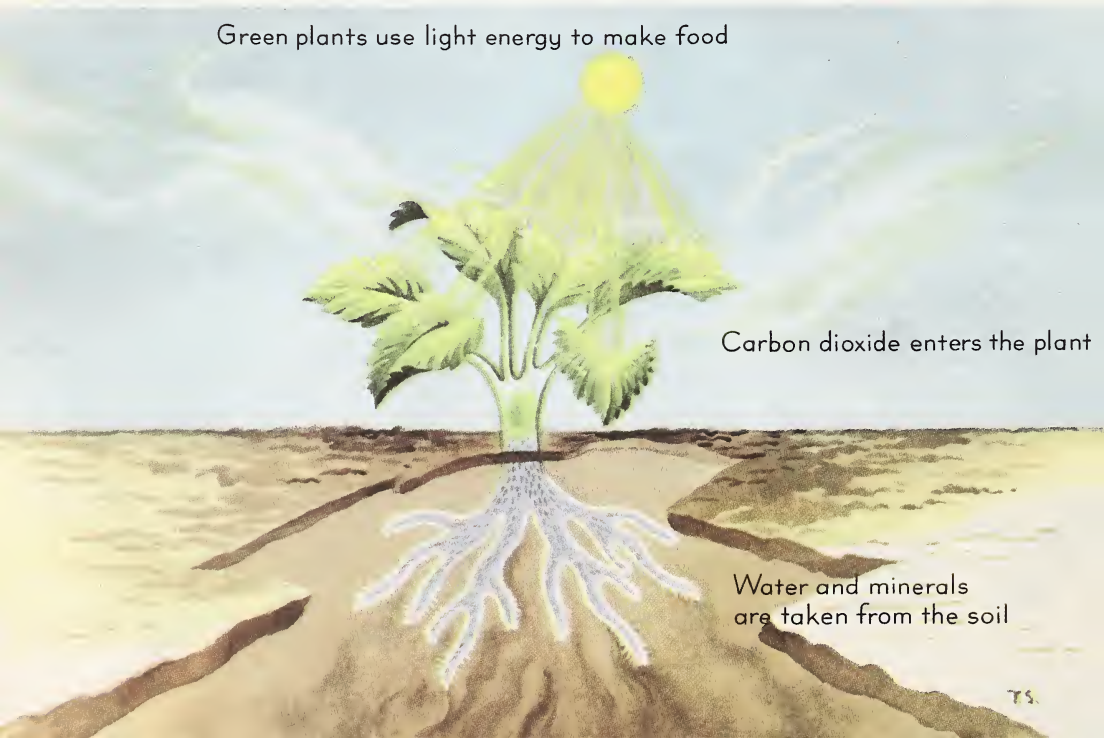
Energy from the sun provides light and heat through the year. Plants do not receive the same amount of energy from season to season. But we have plants in our gardens and fields year after year. Plants are able to make use of changing amounts of energy.

The hours of sunlight and the temperature make a great deal of difference to plants. Even the water that plants need for growth depends on the energy supply. Plants frequently need different amounts of energy to develop.

All plants and all parts of plants are affected by changing amounts of energy. Plants have many different ways of making use of changes in light, heat, and moisture.

Plants and Light Energy

All green plants need light energy. When sunlight falls on their leaves, these plants can make their own food. This is how we think it is done: Water with minerals dissolved in it is absorbed from the soil through the plant roots. The water passes through the stems to



the leaves. Carbon dioxide from the air enters the leaves of the plant. The water and carbon dioxide are changed into plant material by means of green coloring matter called chlorophyll. But wait! This change could not occur if there were not light energy striking the leaves. The energy of the sun falling on the leaves of the plant makes the chemical change possible.

The carbon dioxide and water are changed into a new chemical material, and the light energy is changed into chemical energy. The chemical energy now is a part of the plant. If you eat the plant for food, the chemical energy of the plant will be used by you as muscle energy.

You eat food so that you will have energy to play and work. Hunger is a sign that your energy supply is low. Why don't you just take a bowl of energy from the sun? You don't do this, because you cannot change light energy to chemical energy. Plants can do something that you can't do.

There are many plants which grow with little or no sunlight. These are the non-green plants, such as toadstools, mushrooms, puff balls, and other fungi. The non-green plants too use food to supply energy for growth. But these plants are not able to manufacture their own food. They must get food ready-made.

Some non-green plants attach themselves to green plants. They draw their food from inside the green plants. Others draw their food from the decayed parts of green plants and animals in the soil.

So you see, plants use light energy directly or indirectly. Green plants use sunlight to manufacture food for growth. Non-green plants use the chemical energy of green plants in order to grow.

The amount of light energy which is received by a region has a great deal to do with the kinds of plants able to grow there. The chart on this page shows the length of day at different places in North America on June 22. Notice how many more hours of sunlight there are on that day in Juneau than in Mexico City. The northern regions have more hours of sunlight each day during the growing season. This makes it possible for many plants to grow well in summer in the northern part of the United States and in Canada. From fifty to sixty days after some plants begin growing, they may be ready to harvest.

Hours of sunlight on June 22	
Juneau, Alaska	18¼ hours
Winnipeg, Canada	16½ hours
Seattle, Washington	16 hours
Salt Lake City, Utah	15 hours
Atlanta, Georgia	14½ hours
New Orleans, Louisiana	14 hours
Mexico City, Mexico	13¼ hours

Large crops of hay, wheat, and potatoes and other vegetables grow in some parts of Alaska. The many hours of sunshine each day during the summer help these plants to grow quickly. Harvest time is over before the frosts of autumn begin.

In the northern part of the Central Valley of California, oranges ripen faster than they do in southern California. In fact, the oranges are ready for market several weeks earlier than they are 400 miles farther south. This is partly due to the longer period of sunshine each day during the growing season.

Scientists have experimented with plants to find out how the length of day affects them. They found that some plants produce flowers and fruit only when the days are long. They are called long-day plants. In order to bloom, plants such as lettuce, radishes, and red clover need more than twelve hours of sunlight each day.

Other plants bloom only when the days are shorter, when there are

Arctic plants

fewer hours of sunlight. They are called short-day plants. Tobacco, soybeans, and ragweed are some plants that are short-day plants.

Many plants are neither long-day nor short-day plants. They will bloom when there are many hours of sunlight each day and also when there are few. People who study plants say that most plants probably belong to this group.

Plants and Heat Energy

In most places summer and winter temperatures are very different. On one of the coldest days of winter in Winnipeg, Canada, the temperature dropped to 41° below zero Fahrenheit. In summer on one of the hottest days the temperature rose to 107° F in Winnipeg. The temperature varied 148 degrees. What a great difference that was between the hottest and the coldest day of the year!

In Key West, Florida, in one year a difference of only 51 degrees between the hottest and the coldest day was recorded. In both Winnipeg and Key West the temperature of the air varied. But in Winnipeg the difference in temperature was much greater than it was in Key West.

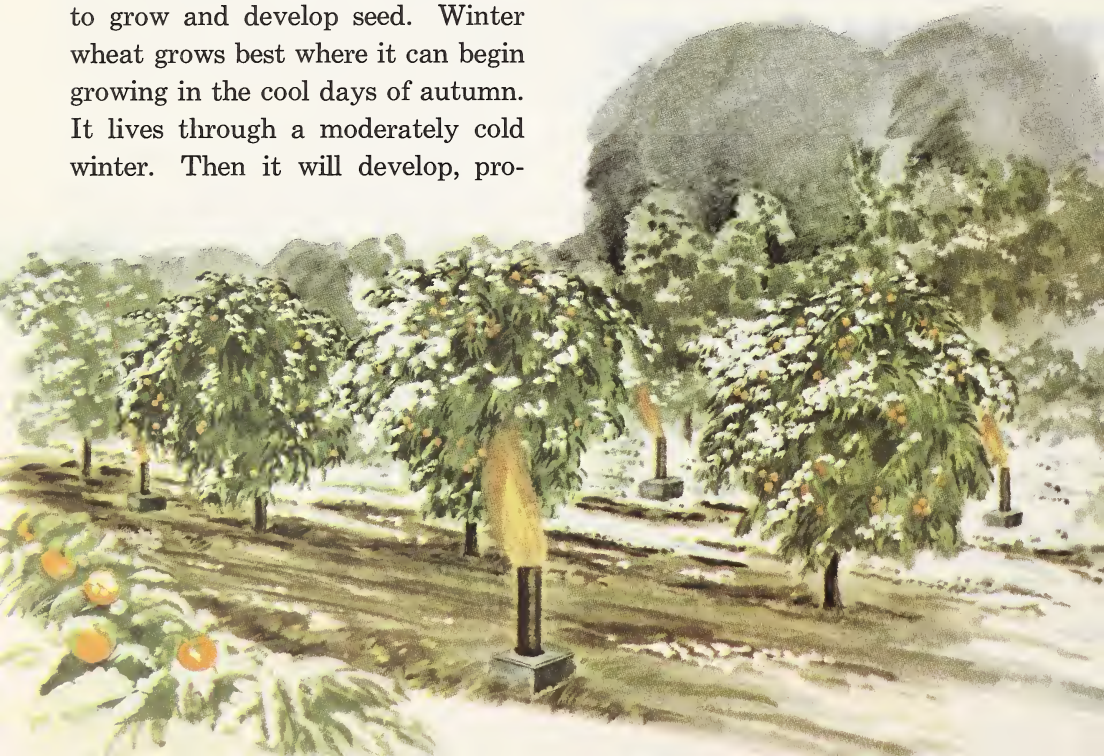
In other parts of the world there are other differences in temperature from one season to another. There are also many places on the earth where the temperature may change very little throughout the year.

Scientists have experimented with plants at different temperatures. They tell us that many plants can stand cold winter temperatures, but during that time they do not grow. In arctic regions some plants live through temperatures far below freezing.

Some plants can also stay alive when the temperature of the air becomes as high as 122° F. However, there is a certain temperature at which each kind of plant grows best. This means that although a plant may be able to live at a temperature just above the freezing point of water, it may grow very slowly. It may not be able to grow to its normal size. If the temperature climbed above 110° F, perhaps the same plant could not grow at all. At a temperature of 80°–90° F this plant may grow its fastest.

Oats, melons, and apple trees need quite different temperatures in order to grow and develop seed. Winter wheat grows best where it can begin growing in the cool days of autumn. It lives through a moderately cold winter. Then it will develop, produce seeds, and ripen in early summer before the heat of midsummer arrives.

Sometimes the temperature of the air changes very quickly. If this happens, plants may be injured. Perhaps you know of places where a sudden drop in temperature killed most of the blossoms on fruit trees. As a result there was little fruit in the autumn. In some places smudge pots are burned to protect the plants from quick drops in temperature that might kill the blossoms or injure the fruit. Plants may also be injured if the temperature rises very quickly.



Plants Continue on Earth

As far back as we are able to search in written records, we find that there have been plants growing. Many of our present-day food plants have been cultivated from the beginning of man's recorded history. Some plants have been cultivated since long before man was able to leave written records of their use.

All the plants which man learned to cultivate and care for existed originally as wild plants. In fact, we think that there were plants on the earth even before there were men. Plants have been on the earth a long, long time.

Think how important such plants as wheat, cabbage, oats, and carrots are to us. Then remember that man has been growing these plants for thousands of years. Cucumbers and onions have been cultivated for at least 4000 years. Rice has probably been grown for more than 6000 years.

How has the supply of rice, cabbage, onions, and other such plants kept up all through these thousands of years?

Some Plants Make Many Seeds

Certain plants grow, blossom, make seeds, and die within a short time. It is possible to grow these plants year after year because each plant makes many seeds. Inside each seed there is a young plant. The young plant can stay alive inside the seed for a long time. Each seed will grow into a new plant when the right amounts of moisture, heat, and light are provided.

When you plant seeds in your garden in the spring, you are planting seeds which were produced by plants during the long, warm days of the summer before. Perhaps you gathered the seeds from the plants yourself. Perhaps someone else gathered seeds from his garden and sent them to the store where you bought them.

Not all seeds are gathered and kept to be planted. Often many seeds fall to the ground. Sometimes these seeds are able to live through the cold of winter. The following spring they will start to grow.

To see this happen, you can try an experiment with a small amount of soil. Put about a cupful of soil in a glass jar and water it. In about a week's time you will probably see some small plants beginning to grow. Yes, there were seeds in the soil. They began to grow when enough heat energy and water were provided.

Plants Store Food

Some plants make seeds and store food in them. Some also store food in their underground parts. The first year, the young plants grow from seeds and develop leaves above the ground. Plants make food during the time when there is plenty of heat and light energy. This food is stored during the growing season in the underground parts of the plants. When cold weather comes, the parts of the plants that are above the ground may die. The underground parts remain alive, but in a resting stage. In this way the plants can live through the winter.

The next year, when there is enough warmth, water, and light, the plants begin to grow again. Later, flowers develop and seeds form. Even

if the plants die, new plants will grow from the seeds.

Certain plants store some of the food made during the growing season in underground parts called bulbs. Onions live through the winter months as bulbs. When the growing season comes again in the spring, the onion bulbs send up stalks on which may grow flowers and then seeds.

When a farmer wants to grow the green onions which we see in the markets early in the spring, he does not plant seeds. He plants small onion bulbs. These grow rapidly because food is stored in the bulbs. When the plants begin to grow, they use this stored food.

If you cut an onion bulb in half, you can see the new shoot in the center. Do you notice the thick leaves surrounding the shoot? These leaves are filled with stored food.

A white potato is made up of food which the potato plant stored in its underground stem. You can do an experiment to see how important this stored food is to the plant. Choose a potato with several well-developed eyes, or buds. You will need to cut three cubes out of the potato, each with a single bud. Make the sides of one cube $\frac{1}{2}$ inch. The sides of the second cube should be 1 inch and of the last cube 2 inches.

Now plant each cube in a separate, small flowerpot and mark the pots. Watch the size of the shoots which come from each of the three buds. Do you see how much larger the shoot is that comes from the bud with the most stored food?

Plants, such as trees, that live on year after year also store food in their stems, but their stems are

Lilac buds

not underground. There is much plant food stored in the trunks of trees.

Water is also stored by plants. Some evergreens hold water in their stems, or trunks, which the plants use when little water is available from the soil.

Many cacti are able to store water to be used when there is no rain. Some have water stored in their stems. There are other plants whose leaves are thick and protected by a tough covering. Water can be stored in these leaves. Perhaps you have seen a plant of this kind called hen and chickens.

Plants Form Buds

Plants that go into a resting stage must have some way of starting to grow again after the winter is over. During warm weather these plants make use of some of their energy to form buds.

Many deciduous trees and shrubs look as if they were dead during the winter, when their branches are brown and bare. However, the branches and roots of these plants stay alive all winter. When the first warm days of spring arrive, tiny green leaves and colored flowers appear on the branches. Where did the leaves and flowers come from? They were there all winter long. You did not see them, because they were tightly folded inside buds on the branches of the plants.

The buds on most trees are covered by scales which protect the leaves and flowers inside the buds from very cold weather. On some plants the bud scales are covered with fine hairs or a waxy substance. This covering protects the buds from losing too much water through evaporation.

You might like to examine the buds on a twig of a willow or a

maple tree or some other deciduous plant. Look at the buds on the sides of the twig. Do you see scales on the buds? Do the scales feel waxy? Are they covered with tiny hairs? Remove the scales very carefully and look at a bud through a magnifying glass. What do you see? If you see tiny, pale-green leaves, gently unfold one leaf after another. You are probably surprised to find so many leaves in just one bud. Notice that they are fastened to a very short stem.

Perhaps the bud you examined had no pale-green leaves in it. Instead, you discovered pale-yellow or pink petals. This bud is a flower bud. It too was formed the summer before.

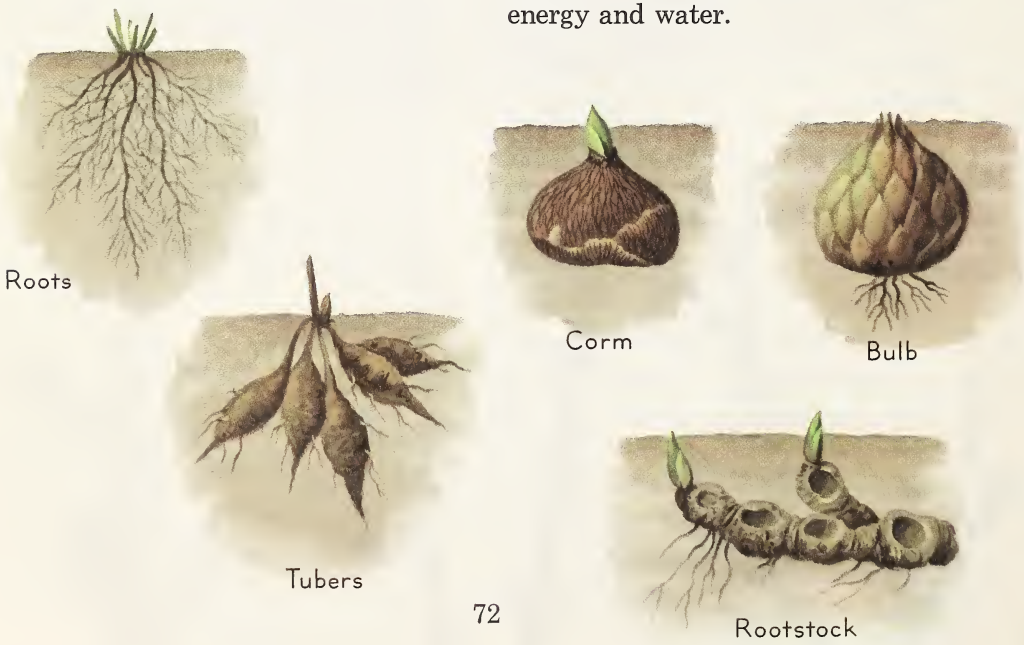
Here is something else you might do: In the late winter or early spring find a tree or shrub that has lost its leaves. Pick out a low branch so that you may look at the buds without harming the plant. It is best not to handle the buds. Look at the buds carefully. How are they arranged on the branch? Perhaps they are opposite each other like these shown in the drawing of a branch from a maple tree.

Some buds alternate on a branch. That is, they are placed one above the other on opposite sides of the branch, but no leaf is exactly opposite any other. The leaf buds of apple and peach trees alternate. On other plants, buds are arranged in a circle around each branch.

Some plants that live year after year do not have woody parts as trees and shrubs do.

Even plants that are not woody have buds which live through the winter. These are not the buds which you see above the ground. You do not usually see these buds for they are underground. On most of these plants the parts above the ground die when the cold days come. To live through the winter, the buds must be formed on the parts of the plants which are protected from the cold.

The underground parts of these plants are not all alike. However, they all live through the winter in a resting stage. They are called rootstocks, corms, bulbs, tubers, or roots. People commonly call them all bulbs or roots. They are protected against the cold air by the soil. Dry grass and leaves which cover the ground also help to protect them. Food is stored in these underground parts. The buds are formed on the rootstocks or bulbs or tubers or other underground parts of the plants. These buds allow the plants to grow quickly when they again receive enough heat and light energy and water.



Climates Change the Way Plants Live

In most places many different kinds of plants are in bloom during the summer. In desert regions, however, there is often so much heat and so little rainfall that few flowers may be seen during the summer months.

In a place such as the Hudson Bay region in Canada one can dig only a short distance during the warmest season before reaching ice and solidly frozen earth. There lichens, moss, small trees, dwarf shrubs, and many other small plants grow. There, too, the summer is so brief that in order to grow well, plants must be able to blossom and form seeds in a very few weeks.

If you live in the southern part of the United States, you may grow many of the same kinds of plants in your garden that boys and girls see farther north. However, many of your plants will grow differently. Some of the flowers and vegetables that grow well in northern regions will not grow at all where the weather is mild all year long.

You are probably familiar with the words *annual*, *biennial*, and *perennial*, which describe plants that live one, two, or more years.

Some plants, such as tulips and hyacinths, which are perennials in the north, must be treated as biennials in the south. New bulbs must be planted every second year in order to have these flowers. Still other plants that are annuals in the north are able to live on year after year in warm regions. This is true of tomatoes. In cool parts of the country these plants are annuals. They may become perennials in places which receive great amounts of energy from the sun throughout the seasons.

The southernmost part of the United States receives more energy from the sun all year long than places farther north do. This means that in some places there may be no frost at all during the year. Plants growing here have a long growing season and a short rest period.

Some kinds of perennials grow well where there is a long rest period each year. But they cannot live through a year-long growing season with hardly any rest at all. Lilacs and peonies are two perennials that do not grow well, if at all, where the weather is warm the year round.

You can see that the amounts of heat, light, and water that plants receive vary a great deal. They vary from one part of the earth to another and from season to season. Changing amounts of energy greatly affect the way that plants grow.

SOME THINGS TO THINK ABOUT

1. When people long, long ago first discovered seeds and how they could use them, their ways of living changed completely. They were able to live in one place instead of wandering in search of animals for food. Can you think of other reasons why the discovery of seeds and their use was important?

2. This is an experiment you can do with biennials that will take several weeks: Plant the whole roots of beets, turnips, and carrots in pots of soil. Label each pot with the name of the root you planted in it. Keep the pots in a sunny place and water the soil when it becomes slightly dry.

Watch your experiment carefully. After several days do you see some green shoots growing through the soil? After some weeks your plants may have flowers. Why?

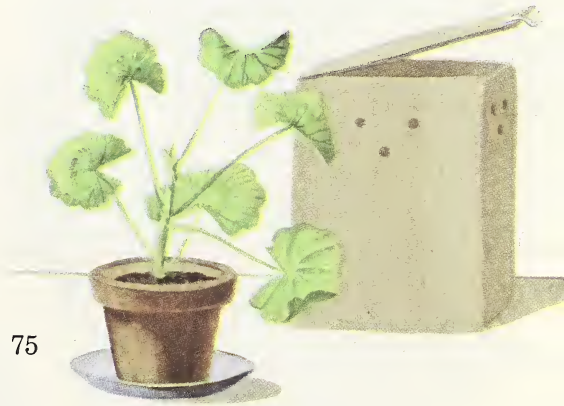
3. Some perennials, like the wild morning-glory, may become so thick that they are pests. Why is it difficult to get rid of these plants by cutting off only the stems and leaves?

4. Carefully cut one or two twigs from trees or shrubs. You may collect forsythia or willow or lilac, but do not cut more than you can use. Put the twigs in water. How do they look after several days? Do the buds all open on the same day?

5. Some plants are long-day plants, and others are short-day plants. How could this information help a florist to have plants in bloom all through the year?

6. You might try an experiment to help you understand what happens to the leaves of a plant when the hours of sunlight are lessened. You will need a cardboard box and two growing geranium plants about the same size. Punch several small holes in the box. The holes will allow air to get in. Cover one of the geranium plants with the box and leave it for three or four hours. Then remove the box from the plant for the remainder of the day. Do this to this same plant each day for a week. Give each plant the same amount of water each day.

Observe the leaves of the two plants carefully. Is there a change in the color of the leaves of one of the plants? If the leaves do not get enough sunlight to keep on making food for the plant, how do they look?



Animals and Seasonal Change

Changes All around Us

There is hardly a place in the world where there are no changes in the weather. Can you think of any place which does not have a change of some kind or another?

Of course you remember some of the changes that have taken place where you live each day, week, and month. We are all familiar with the change from a warm to a cold period and from rainy to sunny weather.

You might expect the weather to stay much the same day after day in the tropics. However, even here there are many changes taking place. There are many regions in the tropics that have long, heavy rains followed by periods of dry, dusty weather.

All the many changes taking place in the weather have an effect upon animals. We might say that when snow falls and the air cools off, some animals cool off also. At times animals are heated and at other times cooled, sometimes moistened and sometimes dried. There are many ways in which animals are affected by the changes taking place around them.

Energy through the Year

As you know, the changes we call seasons are brought about by the changes in the amounts of energy which reach different parts of the earth. In fact, many of the weather changes are the result of the way that the sun's energy reaches our tilted earth. Probably the most important change of all is the change in temperature.

Animals Become More or Less Active

Animals are affected by temperature in many ways. You may have noticed that on a cool summer morning flies usually are not very active. If the morning is very cold, the flies will tend to stay in one spot and not move around very much.

Here is something you might try: You will need a glass jar with a metal screw top. Make one rather large hole and several smaller holes in the cover of the jar. Wrap some cotton around a thermometer and insert it in the large hole so that the cotton holds the thermometer firmly in place. Now catch two or three flies without harming them. Then put the flies in the jar and screw on the top. The small holes in the cover will allow air to enter the jar.

Now you are ready for the next part of the experiment. Place the

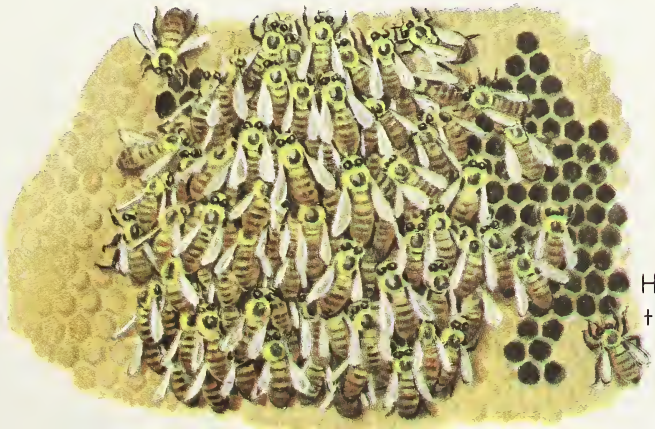
jar in a container of ice, as you see in the picture at the right. In a short time the jar and its contents will begin to cool. Observe what happens to the flies as the temperature is lowered. Do you notice that the flies become less active as the temperature drops? Now remove the bottle from the ice-container. Observe the activity of the flies as the temperature rises.

Not all animals act in the same way as the temperature drops. Some animals become more active, rather than less, when the temperature is lowered.

Probably you have been outdoors in cool weather when a sudden breeze sprang up. If your clothing was not heavy enough and you stayed in the breeze very long, perhaps you became cold and started to shiver. You may say that you became more active. The movement of your body which we call shivering is a way of producing heat to keep your body warm.

Honeybees in their winter groups are able to keep warm by being active. The bees, in a cluster, continuously vibrate their wings. Much heat energy is given off by all this muscle activity, and the hive is kept warm.

So you see that although some animals become less active as the temperature is lowered, others become more active. In fact, the activity helps to keep their bodies warm.



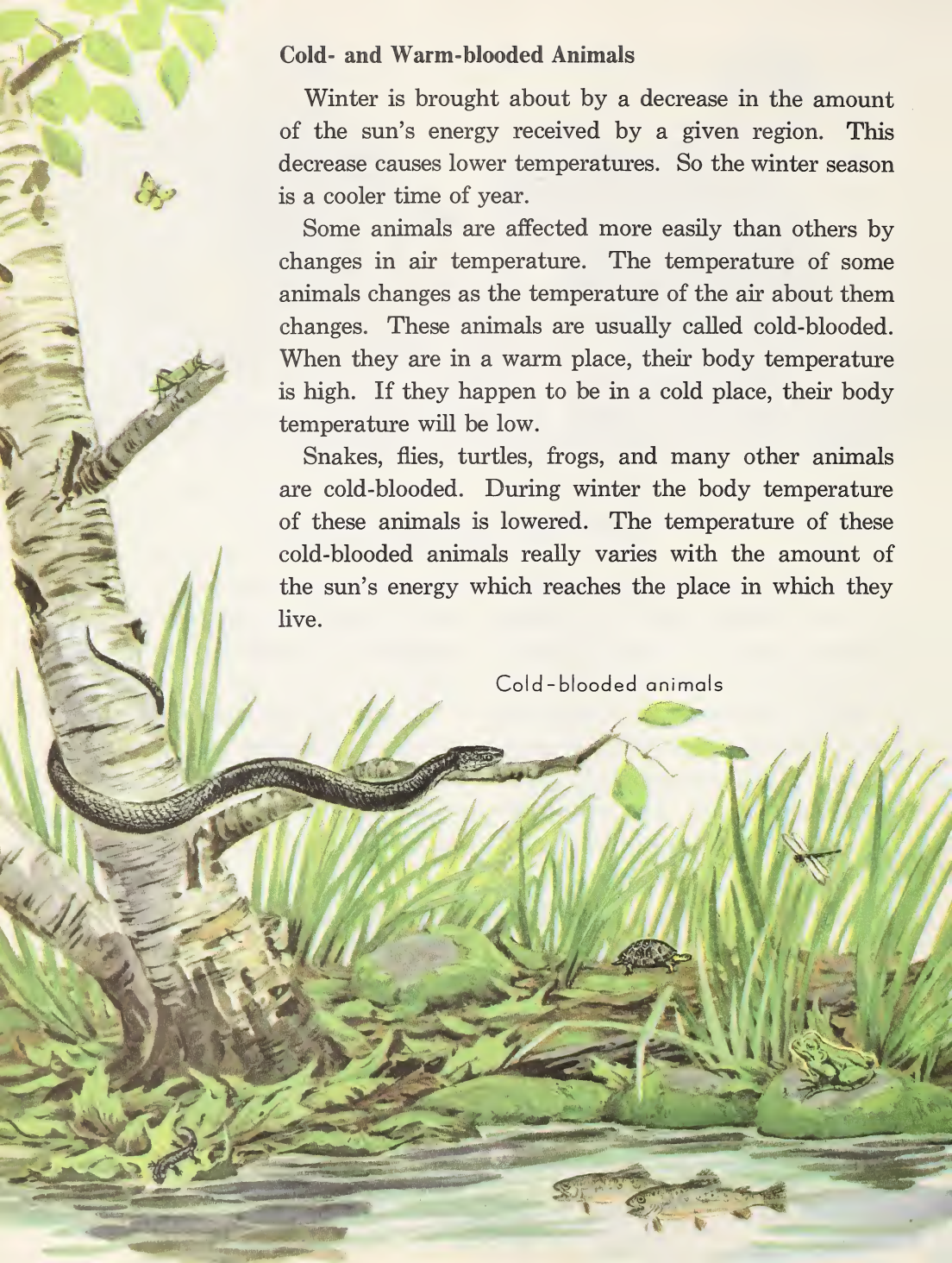
Honeybees in their winter cluster

Cold- and Warm-blooded Animals

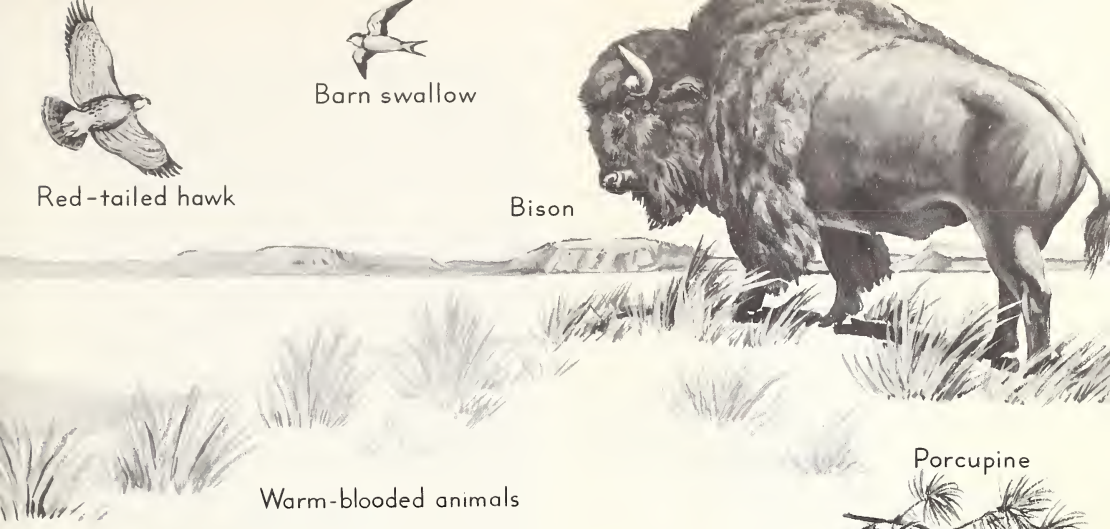
Winter is brought about by a decrease in the amount of the sun's energy received by a given region. This decrease causes lower temperatures. So the winter season is a cooler time of year.

Some animals are affected more easily than others by changes in air temperature. The temperature of some animals changes as the temperature of the air about them changes. These animals are usually called cold-blooded. When they are in a warm place, their body temperature is high. If they happen to be in a cold place, their body temperature will be low.

Snakes, flies, turtles, frogs, and many other animals are cold-blooded. During winter the body temperature of these animals is lowered. The temperature of these cold-blooded animals really varies with the amount of the sun's energy which reaches the place in which they live.



Cold-blooded animals

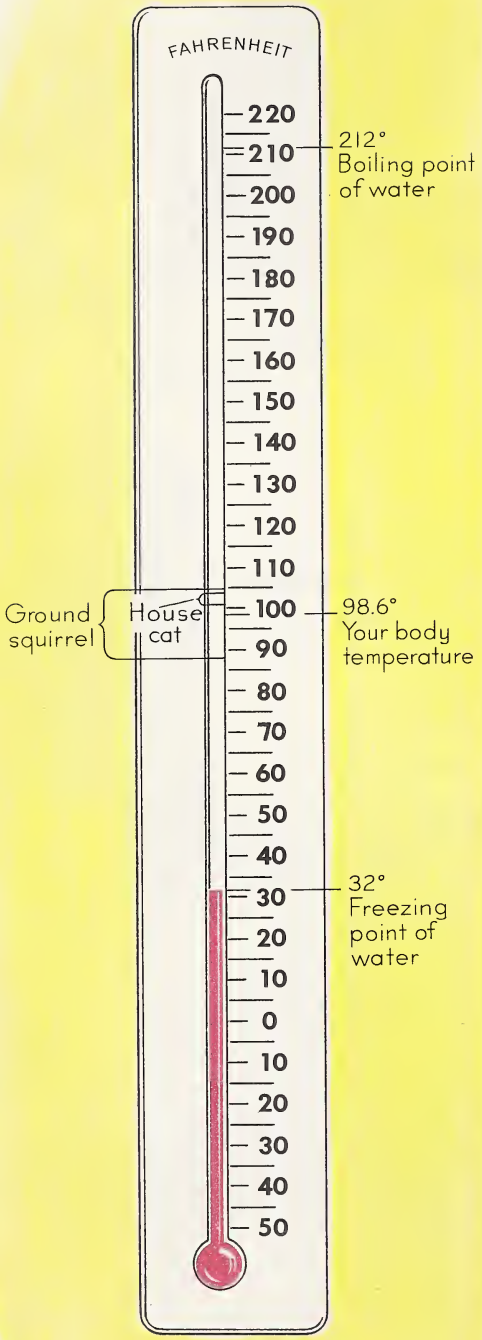


Warm-blooded animals

There is another group of animals, which maintain a rather constant temperature. These animals are called warm-blooded. The body temperature of warm-blooded animals remains at a certain point, even though the places in which they live may be quite cold.

Perhaps you have a thermostat on the wall in your classroom. You know that it automatically regulates the amount of heat in the room. You might say that there is something which acts like a thermostat in the bodies of warm-blooded animals. It regulates the amount of heat in their bodies and keeps them at a rather constant temperature.

Have you had your temperature taken recently? This is probably one of the first things your mother or the physician does to find out if you are sick. Perhaps someone has explained to the class the proper way of using a mouth thermometer. Once you know how to use a thermometer properly, you may be interested in checking to see what your own body temperature is.



Your body temperature is usually about 98.6° F. If your mother found that the temperature of your body was 101° F, she would know that you were sick. We usually say that a person with a temperature much above 98.6° F has a fever.

There is something within your body that regulates your temperature. When you become sick or something else happens to your body, your "thermostat" may not be able to work properly. Then your body temperature may go higher or lower than 98.6° F. This is a danger signal, and something should be done to restore your proper body temperature.

Birds, rabbits, squirrels, and deer are some of the warm-blooded animals. The temperatures of their bodies remain about the same during the different seasons.

The "thermostats" in the bodies of these animals may not regulate their temperature within a narrow range. The temperature of a healthy, active ground squirrel may be anywhere from 88° F to 105° F. This is a range of 17 degrees. As you can see, the temperature regulation of a squirrel is not too precise. The temperature of woodchucks during spring

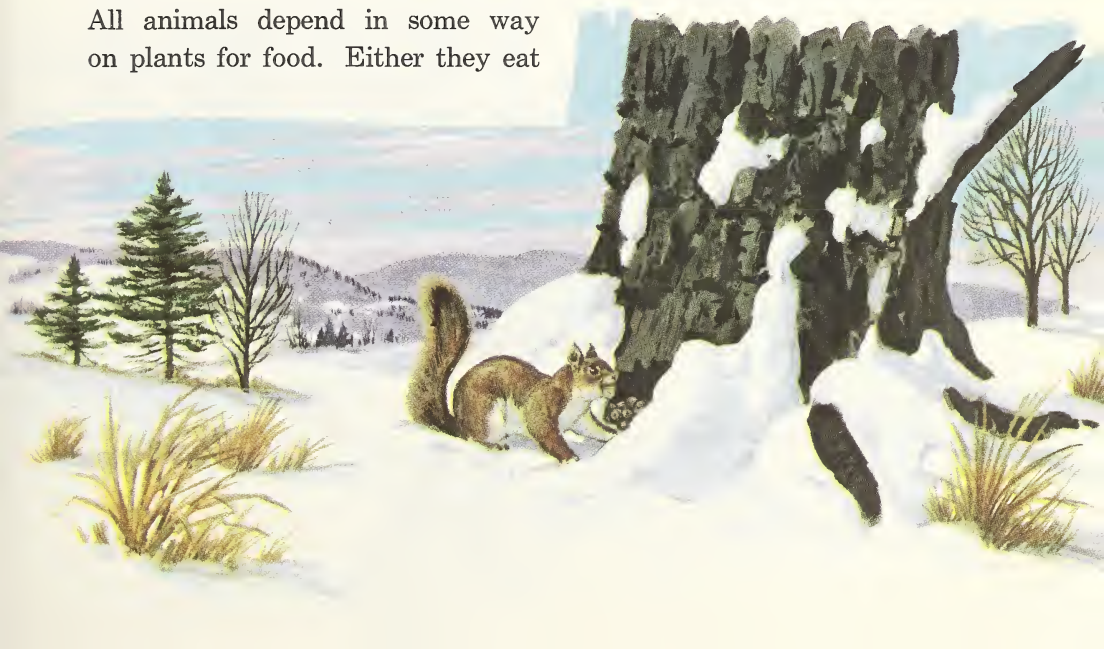
may vary from 94.8° F to 104° F. This is a variation of 9.2 degrees. The temperature of a common house cat may range only from 101° F to 104° F. The temperatures of warm-blooded animals do not rise or fall as the air about them becomes warm or cools. Though the ranges vary, all warm-blooded animals maintain a rather constant temperature within those ranges.

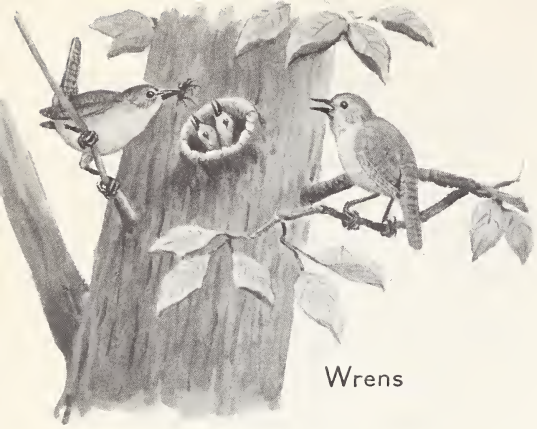
Winter Is a Difficult Time

To continue to live, animals need light, air, water, and food. During winter the amounts of water, food, and light may be decreased. Winter is a difficult time for most animals.

Supplies of food are almost always decreased during the winter season. All animals depend in some way on plants for food. Either they eat plants or they eat other animals, which depend on plants for food.

The most plentiful time of plant production is spring and summer. During winter most plants are in a resting stage. For example, the red squirrel can eat the flowers and seeds of box elder and striped maple during the spring. Then during the summer berries, mushrooms, and the roots of herbs will provide plenty of food. During the winter, however, the squirrel may have to depend upon his harvest of hemlock and pine cones or acorns from oak trees. As the seasons change from summer to fall to winter, it may become very difficult for an active animal to find enough food to keep alive.





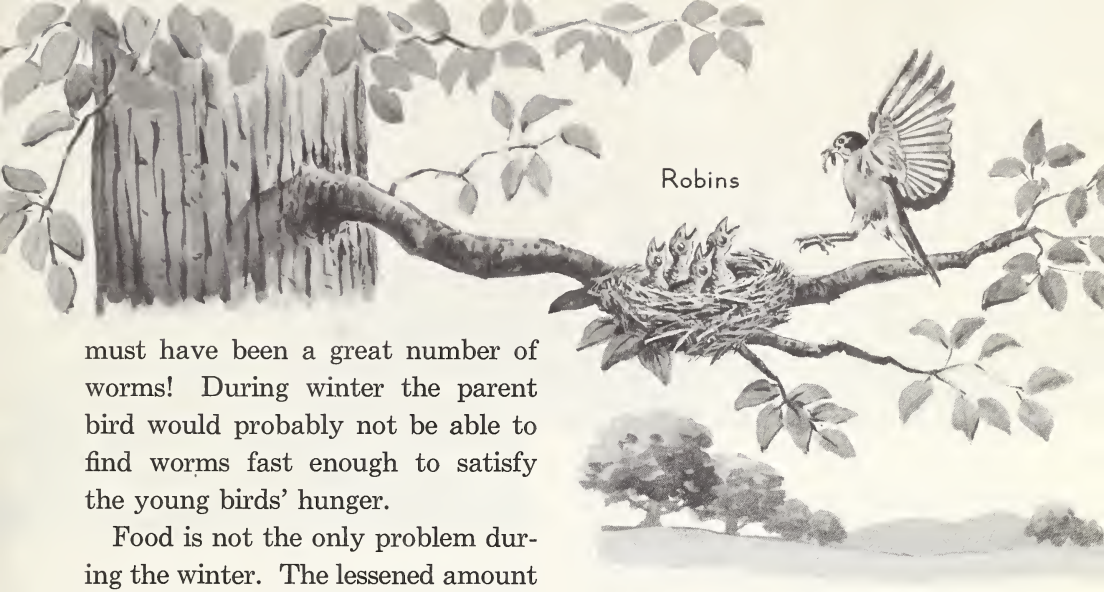
Wrens

Here is something you might do: Observe a nest of young birds during spring or summer. Notice how often the parent bird returns to the nest with food.

You will be amazed at the number of trips the adult bird makes to feed the young. The parent comes and goes so fast that it almost seems as though there were not enough time to hunt for food. We are told that one house wren made about twelve hundred trips to its nest in a little more than fifteen hours.

A feeding experiment was done with a young robin in the spring to find how much food it would eat. It was found that this robin ate 14 feet of earthworms in one day. That

Foxes hunt field mice at every opportunity. As winter comes on and snow falls, it becomes increasingly difficult for a fox to catch enough mice to satisfy his hunger. The fox may then turn to hunting pheasants. If it is a hard winter, the fox may even have to search through the snow in orchards for apples and other scraps of food which may lie covered.


Robins

must have been a great number of worms! During winter the parent bird would probably not be able to find worms fast enough to satisfy the young birds' hunger.

Food is not the only problem during the winter. The lessened amount of heat energy also adds to the difficulties of animals. Most animals live best at certain temperatures. If the air becomes too cold or even too hot, animals may die.

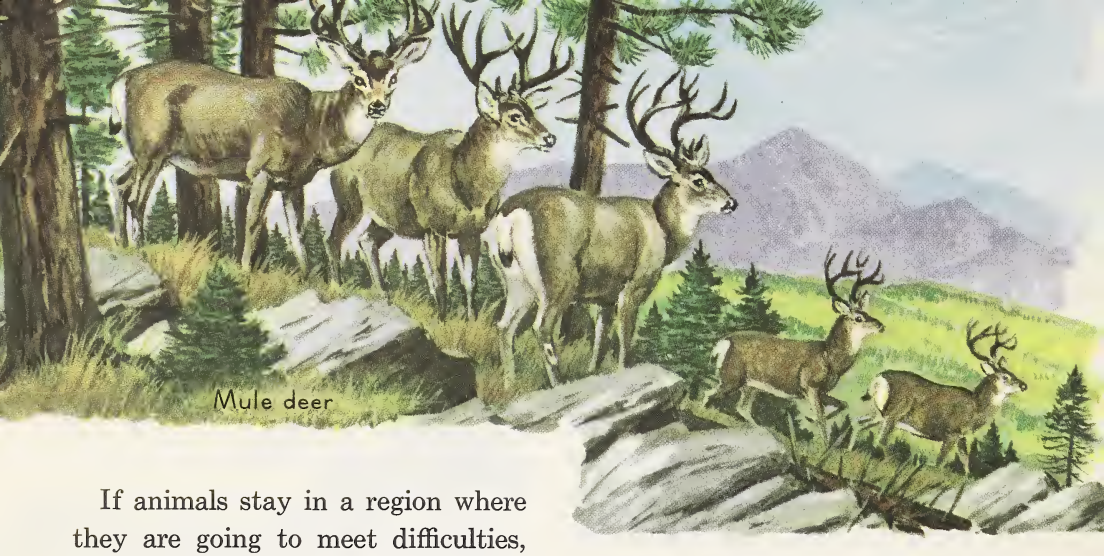
Many cold-blooded animals are killed when their body temperature is lowered to 32° F, the freezing point of water. Many places have temperatures during winter which fall far below this point.

So you see, during winter animals may come up against at least two serious difficulties. Food may become less plentiful, and there may be a drop in temperature. In order to continue to live, animals must be able to overcome these difficulties.

Living through Difficult Periods

As we know, animals do live through the difficult times of winter. There are many ways in which this is possible.

One of the most obvious things an animal can do is to leave the region where life is becoming difficult for it. Many animals do this. They journey to a region where the conditions of heat and food are right for them to continue to live. When the seasons change again, they return to the region from which they have come.



Mule deer

If animals stay in a region where they are going to meet difficulties, then some changes may be made. These may be changes in the animals' bodies and changes in their activities too. Some animals develop thicker coverings of fat, fur, or feathers. These coverings help to protect the animals and make it possible for them to live through the difficult period.

Also, if animals are going to remain in a region, they may go to a place where they are protected. They may go underground, into a tree trunk, under bark, or any other place which will give them protection. They will usually stay in the protected place until conditions are more favorable for them. All these things may make it possible for them to live through a period of difficulty.

Many Animals Migrate

When animals depart from and return to a region during certain seasons of the year, it is said that they migrate. There are a great many different kinds of animals that migrate. Some of these are herring, salmon, eels, certain whales, fur seals, mule deer, monarch butterflies, and a large variety of birds.

It is interesting that the monarch butterfly is one of the very few insects which truly migrate. Most insects do not migrate any great distance. But monarch butterflies may fly as far as from Canada to the southern United States and back again. Large swarms of these butterflies may gather in the northern

United States and in Canada in the early fall. As the butterflies fly south, they can sometimes be seen in late autumn in great swarms along the New Jersey coast. Small trees have been seen there in October completely covered with clinging masses of these butterflies. The butterflies spend the winter in the Gulf states and in the spring they migrate north again.

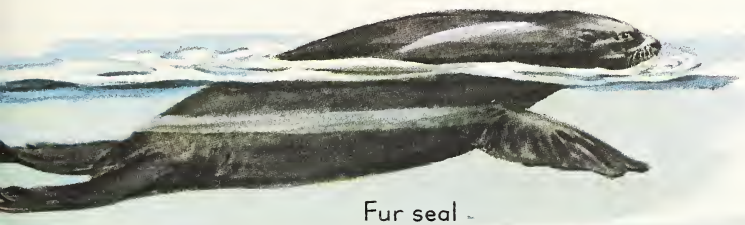
Many birds travel great distances each year. One of the best known of these is the American golden plover. The northern home of the golden plover is along the arctic coast of North America. Plovers arrive about the first week in June and build their nests in the moss on the ground. Young plovers are hatched and after several weeks the young birds are strong enough to fly. Then the long, southern migration begins.

The birds move slowly along the coast of Labrador. They feast on berries and grow fat. In this way they store energy for the long flight ahead of them. From Labrador they cross to Nova Scotia. Then they start out across the ocean for northern South America, 2400 miles

Golden plover

Monarch butterfly

Some migrating animals



Fur seal

Herring

Eel

Atlantic salmon

away. If you follow their route on a map, you will observe that golden plovers fly over Bermuda and other islands in the Atlantic.

Finally, in September the plovers reach their home in Argentina. They have traveled almost 8000 miles from their home in the north! Then about the beginning of March the plovers start northward again. Follow the arrows from the southern home of the golden plover to the northern home. Is it the same route that they took in flying to South America? No one knows just why the plovers fly northward by a different route. By early June the plovers reach their northern home again.

Another great bird traveler is the bobolink. Bobolinks spend the summer in Canada and the northern part of the United States. Here they make their nests and raise their young.

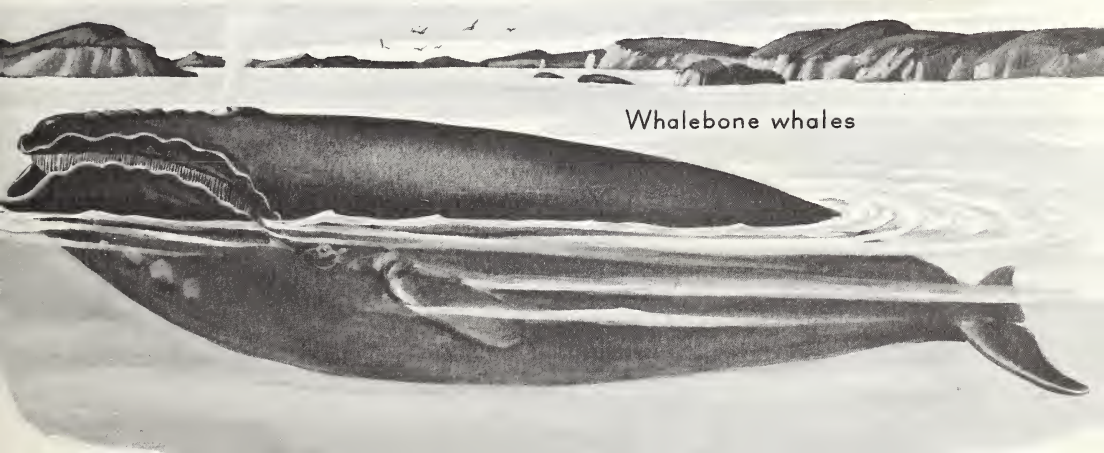
In the autumn bobolinks leave fields and meadows to begin their long journey southward. As they fly south, they stop in North and South Carolina. There they feed on the ripening grains of rice. Often they cause much damage to the rice crop. Bobolinks travel more than 4000 miles to reach their southern home in southern Brazil. They travel most of the way by night, stopping to rest and feed during the day.

Bobolinks

Why Do Animals Migrate?

One cause of migration is probably lack of food. Some of the whalebone whales migrate for this reason. As the seasons change, there are also changes in the temperature of the sea. During summer food is plentiful in the northern seas. At this time these whales may be found in the Atlantic Ocean around Newfoundland.

As winter comes on, the seas begin to cool. Then the food supply of the whales becomes more plentiful southward. As this happens, they begin a southward migration. During winter they can be found off the Carolina coast of the United States.



Whalebone whales

The energy from the sun seems to have an effect on nearly all animal activity. In the case of the whalebone whales it can be seen that the energy from the sun is really influencing the migration. It is the heating and cooling of the sea by the sun's energy that determine where food will be most plentiful. The whales migrate northward and southward to have a continuous supply of food.

Some scientists think that bird migration may be affected by the length of day. Much of their evidence points to the fact that certain birds begin migrating at a particular time of year. It doesn't seem to matter what the weather is like at that time or how plentiful the food is. The only condition that seems to be the same from year to year is the number of daylight hours when migration begins.

Changes in the length of day may bring about changes in the bodies of birds. Longer days may bring about changes which cause them to nest and breed. We know that it is during the longer days of June that some birds move north. Most migrating birds nest and bear young in their northern home.

Another theory helps to explain why the birds go north to nest. Look at the continents in the Northern Hemisphere. Do you notice that their area expands toward the north? The continents in the Southern Hemisphere taper off toward the south. More nesting area is available toward the north during the long days of summer. The large feeding and breeding areas of the north may have led to the annual migrations of birds.

There are many other theories about why animals migrate. No one theory seems to explain all the things that are known about animal migration.

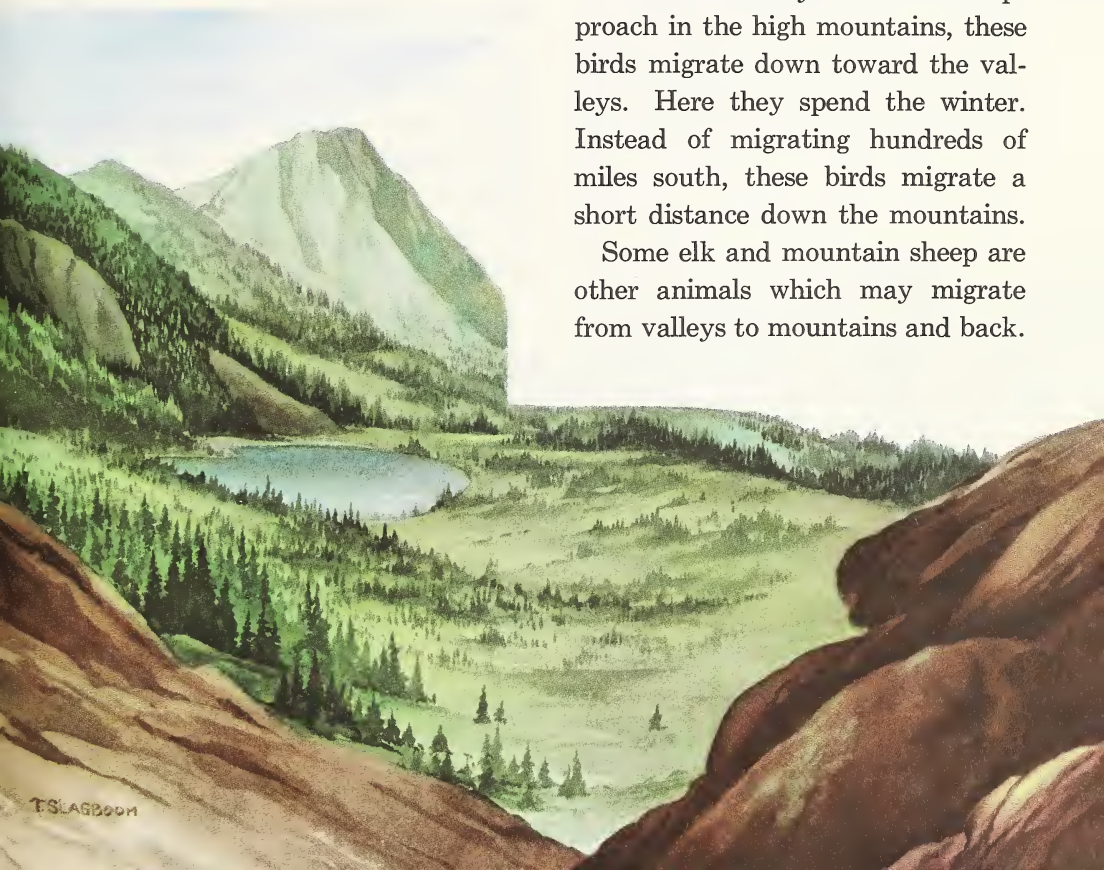
Migrating Uphill and Downhill

Did you know that some animals migrate by traveling up or down a hill or mountain?

On this page is a picture of the western ruby-crowned kinglet. This bird usually spends the winter in the valleys of California. In the spring it leaves the valleys and travels up the mountains. In the mountains the summer is much like summer in Canada. But the western ruby-crowned kinglet travels only a short distance from the valley to the nearest mountain. Six or seven thousand feet up, summer is much like summer at sea level a thousand miles farther north.

As the cool days of autumn approach in the high mountains, these birds migrate down toward the valleys. Here they spend the winter. Instead of migrating hundreds of miles south, these birds migrate a short distance down the mountains.

Some elk and mountain sheep are other animals which may migrate from valleys to mountains and back.



Many Animals Hibernate

Another way in which some animals are able to live through difficult winter conditions is to hibernate. Hibernation has been called by some people "winter sleep." But it is not a true sleep. During hibernation animals remain in a protected place and become very inactive.

Many animals that hibernate are warm-blooded most of the year and have constant body temperature. But during hibernation the body temperature of an animal may be lowered. You might say that its "thermostat" is turned down when it begins its "winter sleep." This helps the animal to conserve its energy and fuel, so that it can live through a long winter.

An animal would freeze to death if its body temperature fell below freezing. Usually an animal will awaken if the air temperature in its winter home gets as low as freezing. But sometimes the animal continues to "sleep" as the temperature around it drops below freezing. Death comes to the animal as it slowly freezes. This is not uncommon, and many animals do not survive hibernation.

Perhaps you live in a region where the ground freezes in winter. If so, you might examine the soil in the side of an excavation that has been made during freezing weather. You will probably notice that only the soil near the top of the excavation is frozen. In some sections of the country the soil may become frozen

to a depth of only 18 inches. But at other places the soil may be frozen to a depth of 3 feet or more. You probably can find out how far down the soil freezes where you live.

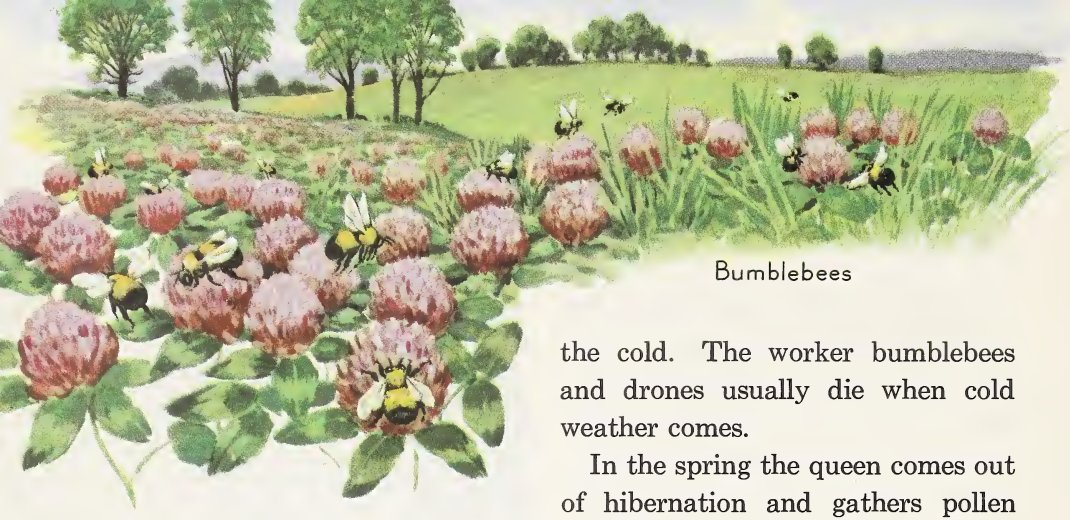
Many animals that hibernate spend the winter in caves or burrows in the ground. These holes or burrows are usually deep enough in the soil so that there is no danger of freezing. We usually say that the burrows are below the frost line. Woodchucks and toads are two familiar animals that hibernate below the frost line.

Woodchucks usually hibernate before the first severe frost. Food may still be plentiful then; so it probably is not lack of food which causes the woodchuck to begin its long "winter sleep."

Before autumn the woodchuck's body develops a thick layer of fat. By late September or early October woodchucks have disappeared from fields and meadows. Most of them have retired to burrows in the ground well below the frost line. These burrows are often lined with grass and leaves. Woodchucks usually remain in their winter homes about twenty to twenty-four weeks.

If we were to look in upon a hibernating woodchuck, we should find it rolled into a ball. The feet would be close together and rigid. The animal would appear to be frozen into a tight ball, with eyes and lips tightly closed.

A woodchuck is normally a warm-blooded animal. But the body temperature of a woodchuck during hibernation is usually about the same temperature as that of the place in which it has made its burrow. Since its burrow is usually well below the frost line, its temperature is probably slightly above the freezing point of water.



Bumblebees

Animals in Protected Places

Animals that hibernate must do so in places that will shield them from direct exposure to the cold of winter. Not all animals hibernate below the frost line during the winter months. Some animals hibernate in other places. It may be a hole in a tree, a hollow log, or a cave. It may be a burrow in the side of a grassy slope.

The queen bumblebee is an animal that hibernates in a protected place. She finds a dry place and digs herself a small nest. Often it is in the old burrow of a field mouse. Here she stays during the cold days of winter. In this way the queen is protected from direct exposure to the cold. The worker bumblebees and drones usually die when cold weather comes.

In the spring the queen comes out of hibernation and gathers pollen and nectar from the flowers. She makes beebread from the pollen and nectar and then lays her eggs. The first young that hatch from the eggs are workers. They do the work of gathering food. Before many weeks there is a full-grown colony of bees.

In the autumn, when the days grow cooler, some kinds of snakes crawl into holes or under logs. Others burrow into the soil below the frost line. There they hibernate until the following spring. Some snakes hibernate alone. Often many of them gather together in one place to spend the winter. Sometimes there are several dozen snakes in one place.

Some animals may awaken, search for food, and return to hibernation several times before spring arrives. On a sunny day in winter you may

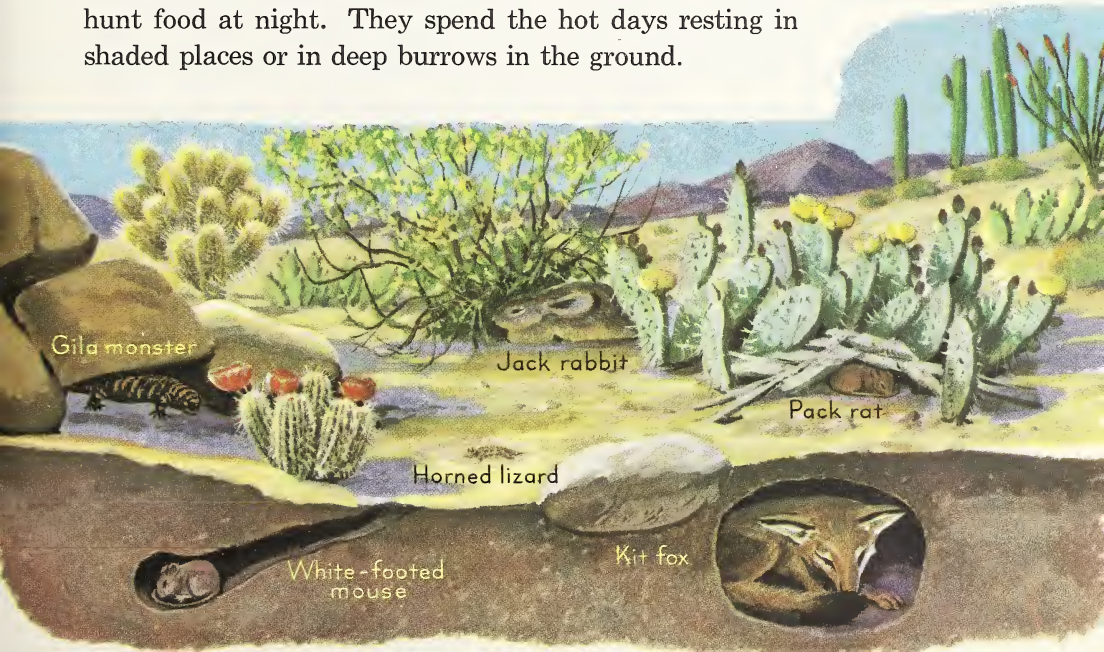
be surprised to see a squirrel scamper across your path. If you watch it, you may see the squirrel paw away the snow and dig into the ground. The squirrel is digging up some nuts that it buried last autumn. After the squirrel has eaten, it returns to its home in a tree. Here it stays during the very cold days of winter, hibernating.

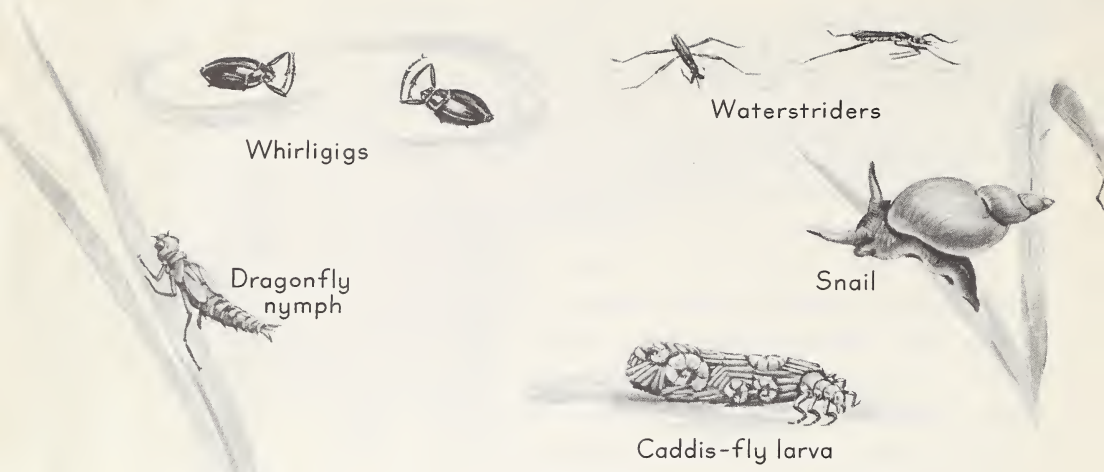
During any of the winter months when it is warm enough for the snow to melt, opossums may be found in the woods. These animals are searching for food. Then when the weather becomes cold again, they return to their winter homes in hollow trees. Here they remain until warmer weather may awaken them, and they again leave their homes in search of food.

Opossum

Animals during Dry Seasons

In some parts of the earth the dry, hot season is the most difficult time for animals to stay alive. Some animals that are usually active during the daytime change their habits. During the dry, hot season they hunt food at night. They spend the hot days resting in shaded places or in deep burrows in the ground.





Some snakes and lizards that live in deserts spend the day under rocks and bushes. At night, when it is cooler, they come out and hunt for food. The desert sunlight has too much heat energy for them. They are cold-blooded animals, and their body temperatures would be raised by the desert sun. If they remained in the sunlight, they might be heated too much and die. You might even say that they would be cooked by the sun.

Other animals remain inactive in protected places during dry, hot weather. Some snails are able to live through long periods of drought. They crawl into a protected place and make a substance which seals the opening to their shells. They remain inactive until the next rain. Then during the moist weather they live an active life again.

Sometimes ponds dry up during an unusually hot summer. Many of the animals living in these ponds bury themselves in the mud in order to stay alive. If you can find such a pond near where you live, get a shovelful of soil from the pond. Put the soil in a bucket or pan. Then add water to the soil. Do you see any living things swimming around? Look at the pictures at the top of this page. You might see some of these animals.

There is some kind of seasonal change during the year in almost all

parts of the world. Some of these changes bring a variety of conditions which make life difficult and dangerous for living things.

Each kind of animal has its own particular way in which it continues to live through periods of change and difficulty. We know that migration, hibernation, and changes in the bodies of animals provide ways in which animals rest and live through difficult times. But there is still much to learn. In the next few years we shall probably learn of many new discoveries about how and why these changes take place.

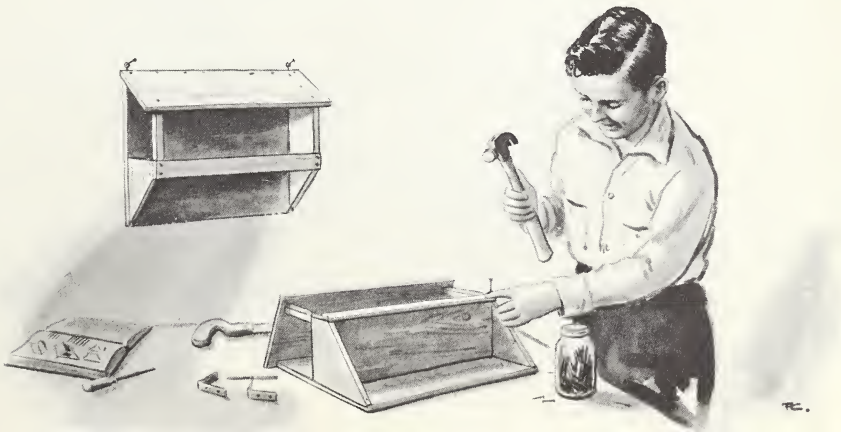
LEARNING MORE ABOUT ANIMALS

1. During autumn watch the animals in your neighborhood. What changes do you notice? Are some animals disappearing? You might keep a record of your observations.

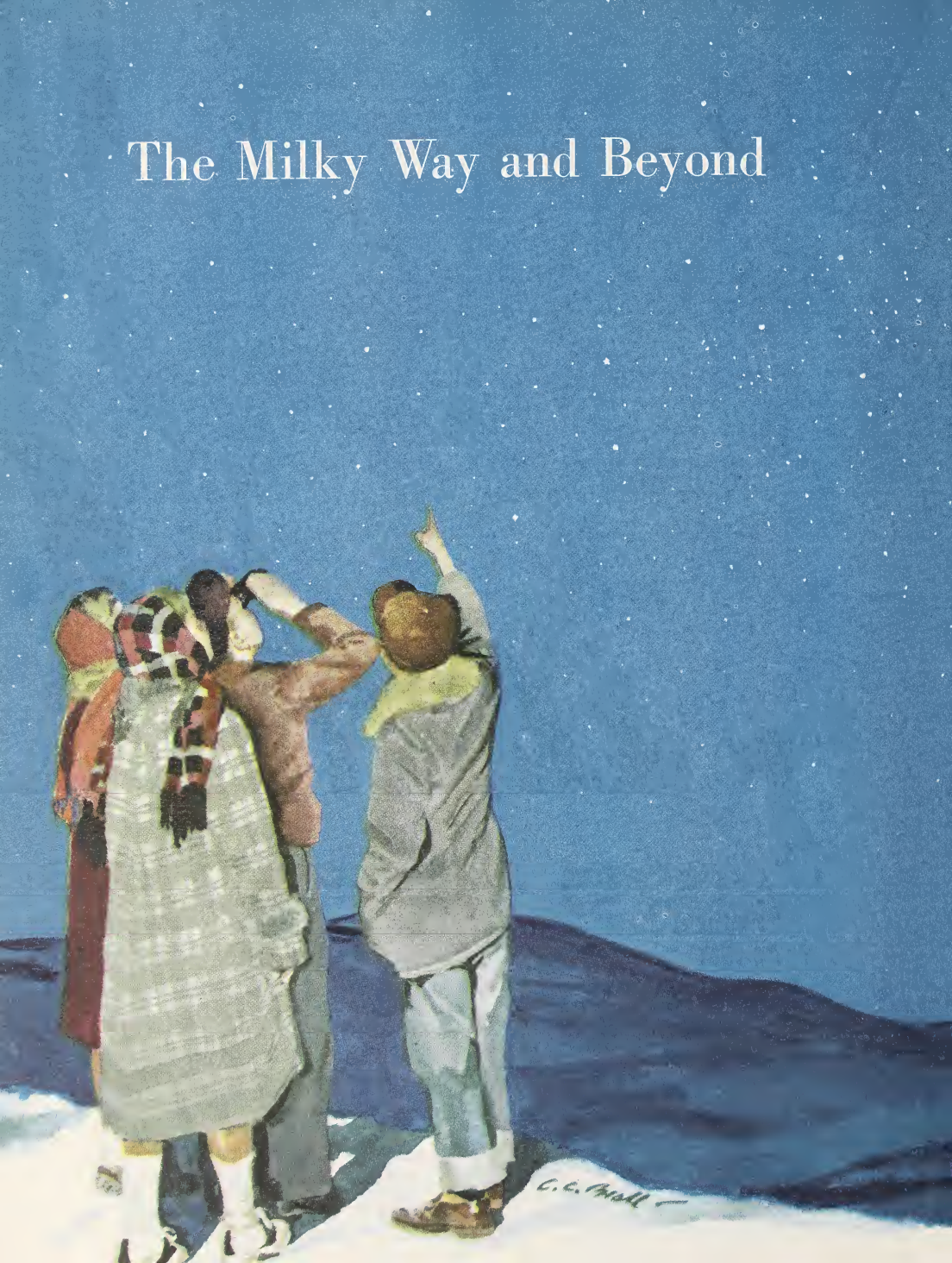
2. Keep a record of the birds you see during each month of the year. You will discover that some birds come early in the spring and spend the entire summer in your community. These birds are called summer residents. During autumn these birds will probably leave your community and fly south.

Some birds spend only the winter in your community. We call these birds winter residents. They spend the summer farther north and migrate south to your community for the winter.

3. You might build a feeding shelf for birds in winter. It will be interesting to watch the birds that are winter residents in your community. Besides providing food for the birds, the feeding shelf will give you a chance to study them as they come to eat. What foods do they prefer?



The Milky Way and Beyond



What Is the Milky Way?

Perhaps you have been out in the open country on a clear, moonless night. If you have, you may have seen a wide band of pale-white light that stretches across the sky among the stars.

Because of its whitish color and appearance this band of light has been called the Galaxy. *Galaxy* comes from a Greek word which means "milky." Many ancient people thought of it as a kind of highway, and so it came to be known as a way. It was called the Milky Way.

The Milky Way may seem to begin on the horizon and stretch up over your head, across the sky, and down to the horizon behind you. As you look at it, you may ask, "What can it really be?" You know that there are stars, planets, and comets in the sky, but what is the Milky Way?

A portion of the Milky Way

You could get a better look at the Milky Way if you had a telescope to use. With a telescope you would be able to see that there are more stars in the Milky Way than anyone could possibly count. This band of light is really coming from millions and millions of glittering, sparkling stars.

You do not need a strong telescope to see that the Milky Way is made up of stars. Almost any pair of good field glasses, or binoculars, is strong enough.

If you are planning to look at the Milky Way, be sure to pick a clear night when the moon is not visible. You will be able to see more clearly if you are far from city lights. As you look through the glasses, you will see that this cloudy veil of light is made of a vast haze of stars. They seem to be very small and crowded together.

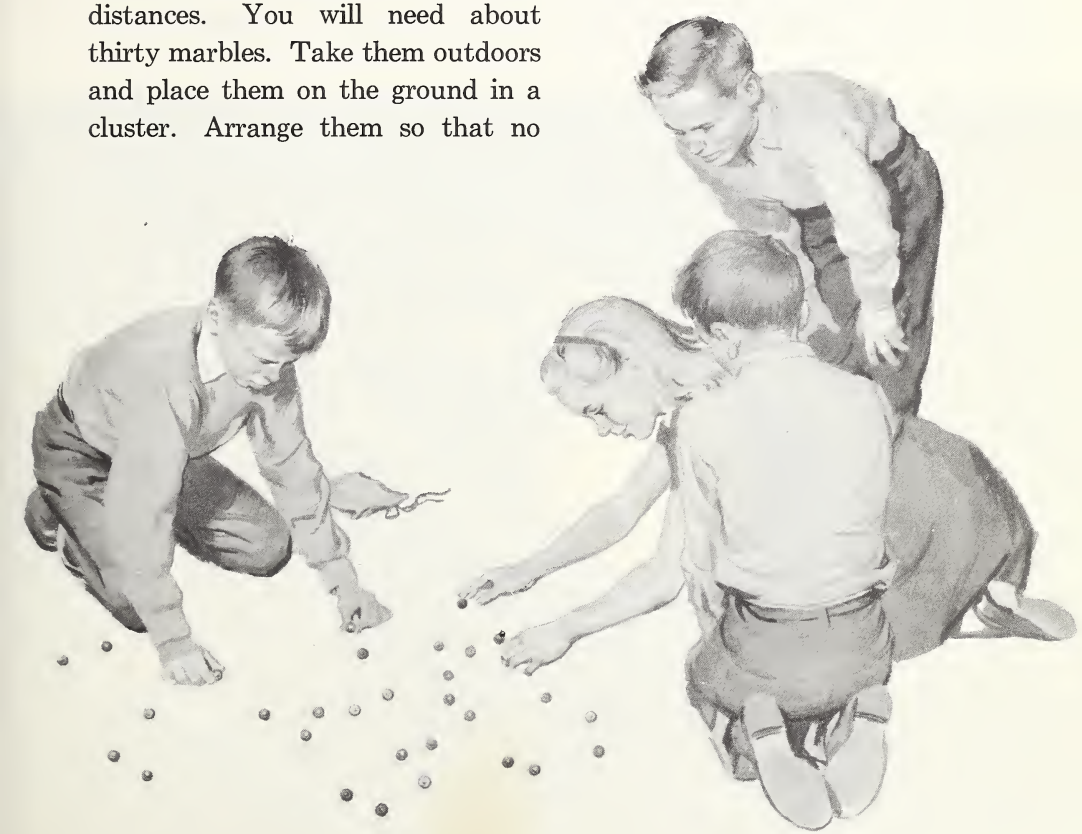
Without a telescope or glasses we cannot see many of the stars themselves in the Milky Way. This is because they are so very far away. We can see only the glow of light from all of them, arching across the sky. If we could follow this band of light, we would find that it appears to form a complete ring around the earth. The earth seems to be surrounded by this far-off band of billions of stars.

Stars Are Far Apart

As you look at the Milky Way, the stars appear to be very small and close together. Actually, even in what looks like a thick cloud of stars, each star is far away from its nearest neighbor. They seem to be packed closely together because they are all so very far away from you.

You might try an experiment. It will help you to understand why the stars seem to be close together, though they are separated by great distances. You will need about thirty marbles. Take them outdoors and place them on the ground in a cluster. Arrange them so that no marble is less than an inch from its nearest neighbor. You can see how this has been done in the picture.

Now stand so that you are looking toward the marbles. Slowly back away. As you back away, you will notice that the marbles seem to be moving closer together. Move about 50 feet from the marbles. Are you surprised to see how close together the marbles seem to be?

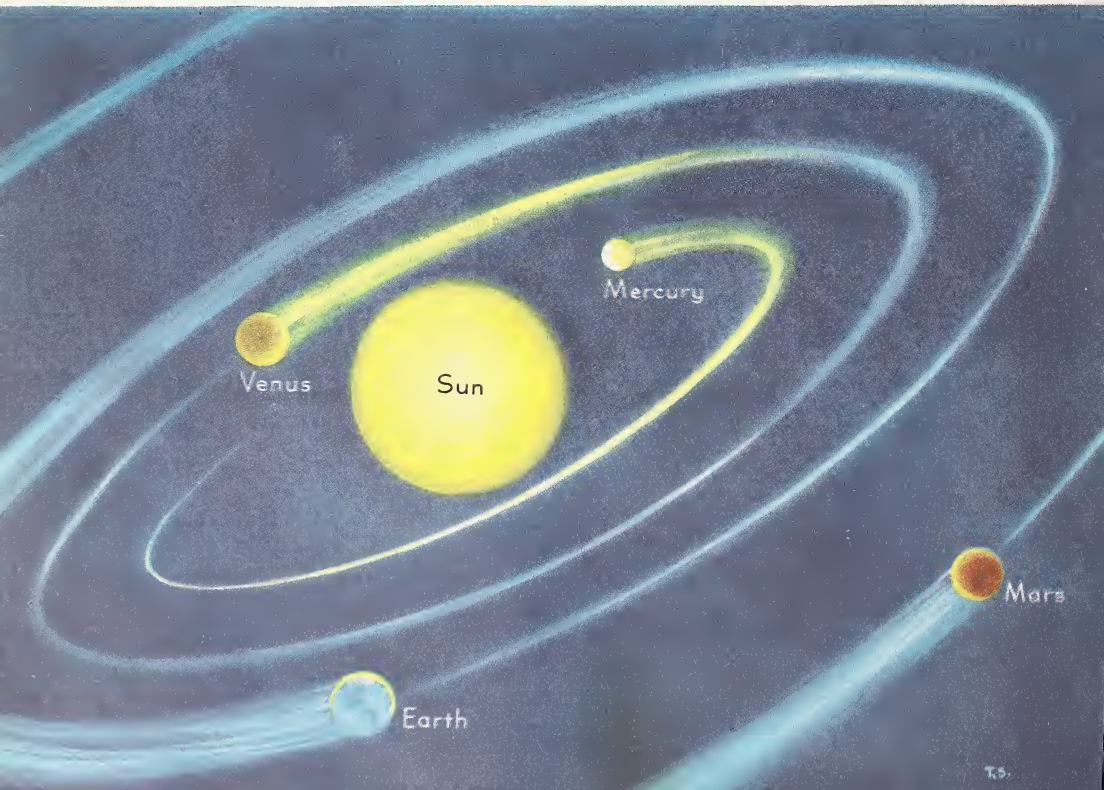


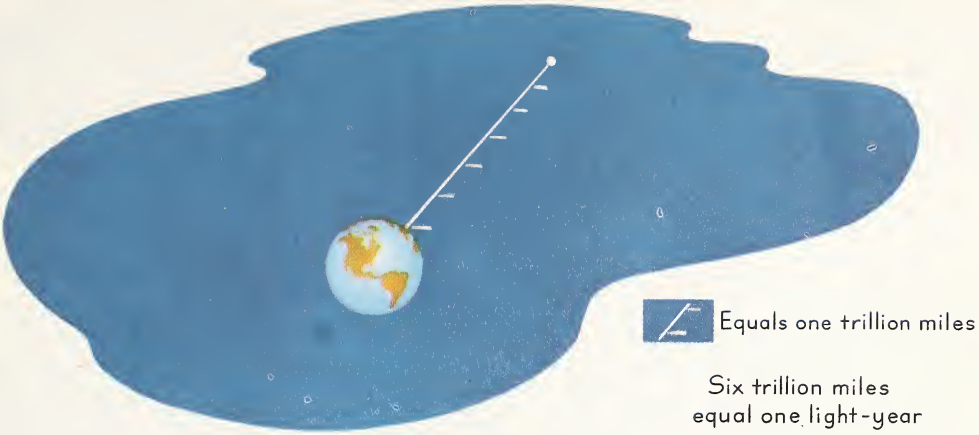
At about 100 feet you will probably not be able to distinguish the separate marbles in the cluster. But you will be able to see that they are of many different colors. Now if you use a pair of field glasses to look at the cluster, you will be able to see the individual marbles. Do you see that if you are far from a group of objects, the objects appear to be crowded together?

This is similar to what happens when you look at the Milky Way. You are so far away that the Milky Way appears to be only a band of light. When you use a telescope, you can see many individual stars which make up the group.

Distances in the Sky

Do you remember which star is closest to our earth? It is our own star, the sun. Three planets are sometimes nearer the earth than the sun is, but planets are not stars. Planets shine because they reflect the light from our sun. Stars are so hot that they glow with their own light. They are much like our sun. Some of them are bigger than our





sun, and some are smaller. We could say that all true stars are suns, or that suns are stars.

We can feel the warmth of the sun as it shines so brightly in our sky. Because of this we might think it is near the earth, but actually the sun is very far away. It is farther away than any place on earth. The sun is about 93 million (93,000,000) miles away from the earth. That is a rather long distance, isn't it?

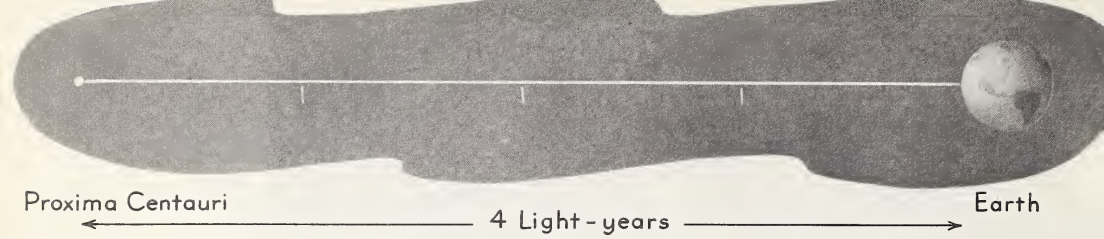
You might try to think of it in this way: Suppose you traveled toward the sun at a speed of about 700 miles an hour. Even if you traveled at this speed all day and all night, month after month, it would take you about 15 years to get to the sun. That is probably longer than the time that you have been alive.

Our sun is much closer to the earth than any of the other stars are. The next nearest star is more than 24 trillion (24,000,000,000,000) miles away from us. This star is called Proxima Centauri. If we traveled at 700 miles an hour, a trip to Proxima Centauri would take about 4 million years.

A Light-year

If the distances to the stars were measured in miles, the numbers would be very, very large. The numbers would also mean very little to us. After all, it is difficult for us to imagine 24 trillion of anything.

Astronomers use another way of measuring distances to the stars. Instead of saying that a star is so many miles away, they say that a star is so many light-years away.



A light-year is the distance that light energy travels in one year. Scientists have discovered that light travels about 186,000 miles a second. But that is only the distance traveled in one second. To find how far light travels in one year, you must first find how far light travels in one minute, in one hour, in one day, and then in one year. If you solve this problem, you will find that light travels about 6 trillion miles in a year.

Astronomers found that this figure was too large to work with easily. So instead of saying 6 trillion miles, they use the term *1 light-year*.

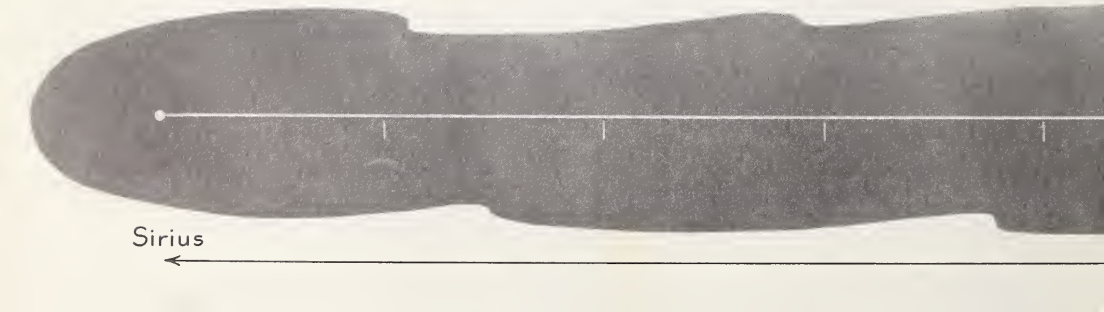
An astronomer might say that the distance to an object in the sky is 1 light-year. He means that to reach that object, one would have to travel about 6 trillion miles.

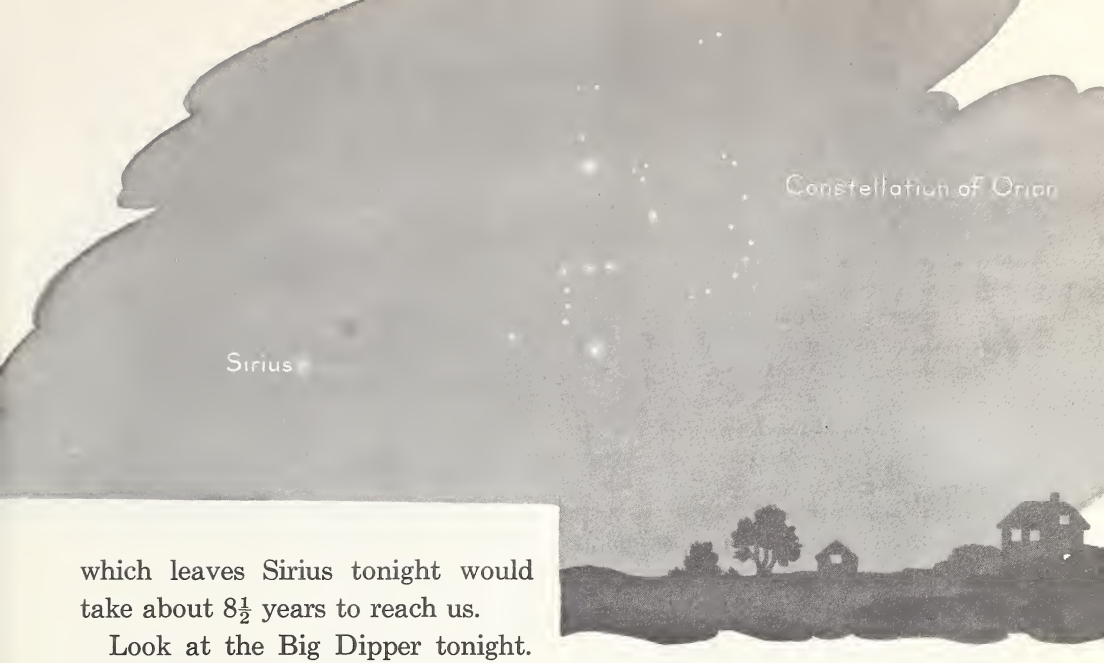
Using Light-years

The nearest nighttime star that people living north of the equator can see with the naked eye is Sirius. It is a very bright star in the sky during the winter and early spring. Sirius is about 50 trillion miles from the earth. It is about twice as far away as Proxima Centauri.

Instead of saying that Sirius is 50 trillion miles from the earth, astronomers say it is about $8\frac{1}{2}$ light-years away. If we should see Sirius in the sky tonight, we would know that the light by which we see it left the star about $8\frac{1}{2}$ years ago.

We might think of this distance in another way too. Let's suppose that Sirius should stop shining tonight. We would keep on seeing light from it for about $8\frac{1}{2}$ years more. This is because the light



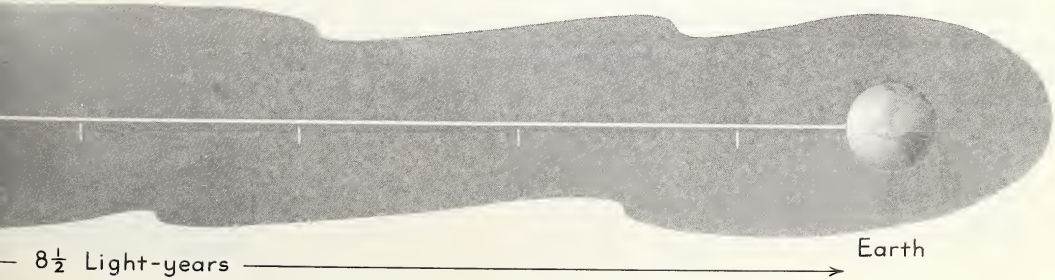


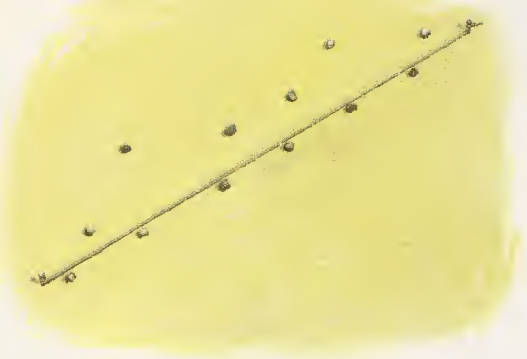
which leaves Sirius tonight would take about $8\frac{1}{2}$ years to reach us.

Look at the Big Dipper tonight. Some of the stars in the Big Dipper are about 100 light-years away. When you see them in the sky at night, the light you see left those stars about 100 years ago. That is longer than the lifetime of most people.

Stars around Us

Notice the picture of the constellation Orion on this page. You might look for Orion in the sky in the winter or early spring. You probably know that a constellation consists of stars which seem to form a picture in the sky. Although the stars in each constellation appear to be a part of a single group, they are really not related to each other in any way. Some of the stars may even be millions of miles farther away from the earth than other stars in the same constellation.

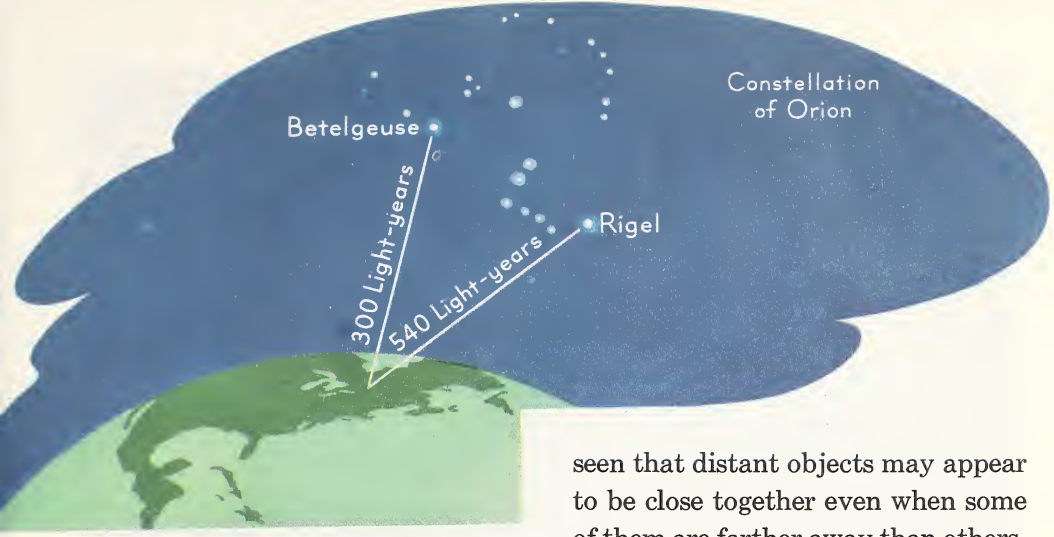




Here is something you can do to help you to see how this is possible: With a ball of string lay out a straight line about 12 feet long on the ground. Arrange a dozen stones on the line about 1 foot apart. The stones should be about the size of a tennis ball. Then move six of the stones straight back from the line, as you see in the picture. You will notice that they have been moved different distances. You might move two of them about 6 inches, two about 1 foot, and two about 2 feet back. Now you will have one row of six stones in front, and you will have six other stones at different distances behind the first row.

Walk about 50 feet away from the stones and look at them. Move 100 feet away and look at them again. As you move farther away, it becomes more difficult to see that some of the stones are at different distances from you. If you move far enough away, the stones will actually appear to be in a straight line again.

This may help you to understand why the stars in each constellation seem to be part of a single group. In



the constellation Orion are two very bright stars. They are called Betelgeuse and Rigel. Because these stars seem to be near each other in the sky, we might think that they are about the same distance from the earth. Betelgeuse is about 300 light-years away. That is, it takes the light energy from Betelgeuse about 300 years to reach the earth. But Rigel is so far away that its light takes about 240 years longer than that to reach us. This means that Rigel is about 1440 trillion miles farther away from the earth than Betelgeuse is.

We say that these two stars are in the same constellation because they happen to be in the same direction from the earth. You have seen that distant objects may appear to be close together even when some of them are farther away than others. The stars which we see as a constellation are actually at quite different distances from us. So you see, the grouping called a constellation is an invention of man's imagination. It is a useful invention too because it helps us to pick out various stars easily.

When we think of such great distances, we can begin to realize how huge space is, and how small our earth. Yet to us the earth seems large.

The sun, our daytime star, is very much larger than the earth. It is important to us because it gives us light and heat energy, but our sun takes up only a small part of space. There are billions of other suns far beyond our solar system.

The Milky Way System of Stars

An astounding discovery was made by astronomers. They found that the stars in the sky do have a certain relationship to each other. Scientists tell us that all the stars that we can see with the naked eye are part of a single system of stars. This means that the Milky Way is not just a separate band of stars surrounding the earth. It is related to the rest of the stars in the sky, and it is related to our sun. Together our earth and the sun and the Milky Way and all the other stars we see make up one vast system. This system of stars is called the Milky Way system or the Galaxy or often simply the Milky Way.

Even more astounding was the discovery that there are other huge collections of stars out in space. These vast systems are also called galaxies. They are so far away that most of them cannot be seen without the aid of a telescope. The few that can be seen with the naked eye do not look like stars at all, but like small blurs of light.

The Shape of Our Galaxy

About 1785 William Herschel, one of the greatest astronomers, made a map of the stars. He counted the number of stars in different parts of the sky. Herschel believed that in this way he could find out how the stars in our system are arranged.

Of course it was impossible to count all the stars. So he counted the stars in portions of the sky. As he looked through his telescope, he found that there was a great difference in the number of stars in different parts of the sky. Looking toward the Milky Way, he counted many, many stars. When he looked in other directions, he counted a much smaller number.

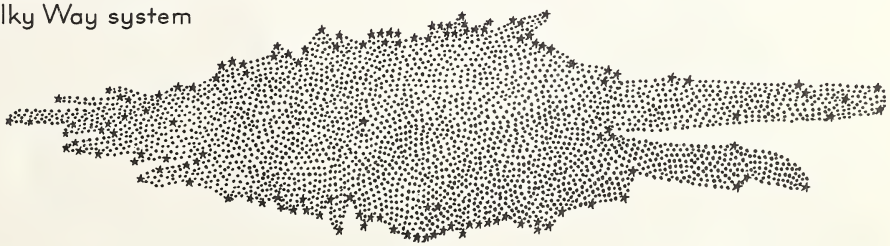
Herschel began to realize that there was an end to our system of stars, even though he could not see it. He also realized why the stars seem more numerous in some directions than others. He said that this is due to the shape of our system of stars and the earth's position within that system. The stars in our Galaxy seem to form a large wheel which is slightly thicker at the center, or hub.

In the picture below you can see Herschel's map of our Galaxy. He based his map on his star counts. Herschel said that the earth and our sun are part of this tremendous system of stars.

Our Sun and the Galaxy

To us on earth it seems that our sun is not a part of the vast group of stars we see in the sky at night. It seems this way because the other stars are so far away. The light from our sun is so bright that we are not able to see the other stars in the daytime. If we could travel far out in space away from the sun, we

Herschel's map of the Milky Way system



should see that our sun is really a part of the Milky Way system. As we looked back from outer space, we should see that the sun is surrounded by the other stars in our Galaxy.

Working with better telescopes and other tools, modern astronomers have located our earth and sun in this system more accurately than Herschel was able to do. They find that the sun and its family of planets are about halfway between the center of the Milky Way system and its rim. These astronomers have estimated that the diameter of our Galaxy is about 100,000 light-years. They say that at its center it has a thickness of about 10,000 light-years.

When we think of the earth's position in this great wheel of stars, it helps us to understand the appearance of that band of light we call the Milky Way. Here is something you can do to show this: You will need two glass pie plates and some brightly colored cellophane tape.

Stretch a piece of tape across the center of one of the pie plates from one side to the other. Now fasten a second piece of tape as you see in the picture below. It should cross the first piece about halfway between the center of the plate and its side. Tip the second pie plate upside down on top of the first and you will have a crude representation of the shape of our Galaxy. The point where the two pieces of tape cross represents the position of our sun and earth about halfway be-

tween the center and the rim of our Galaxy.

Now let's imagine that our pie-plate Galaxy is "filled" with stars. Of course the stars are far apart, but there are many of them. Can you see that there would be room for a great many stars between the earth and the rims of the pie plates? When we look toward the rims, we see so many stars that they seem crowded together. We call these stars the Milky Way. Looking from the earth toward the bottom of either plate is a much shorter distance. There are not so many stars between us and the space beyond our pie-plate Galaxy.

Another way to think of it is that it is as if we were halfway between the hub and the rim of a great starry wheel. When we look at the Milky Way, we are looking toward the rim of the wheel. There are so many, many stars between us and the rim that we cannot see them separately. If you think that you may be looking across the center of the wheel toward the rim on the far side, it helps you to realize why you see only a shining band of light instead of separate stars. However, when you look at the sky apart from the Milky Way, you are looking up out of the wheel. There are fewer stars, and so you can see the individual stars more clearly.

The whole Milky Way system, made of billions of suns, is moving through space. As it travels through

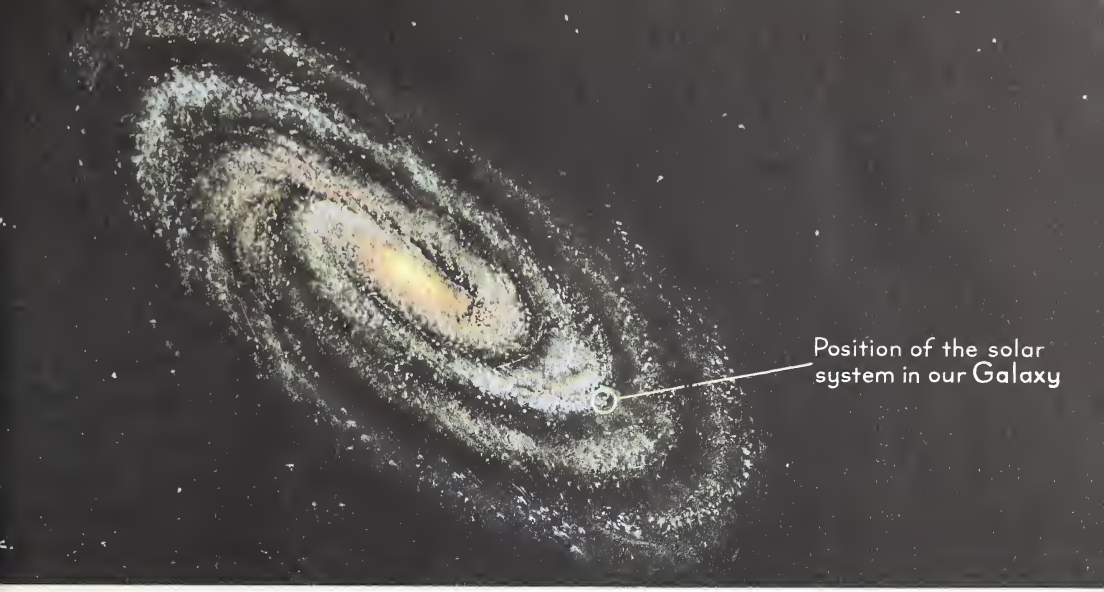
space, this tremendous system moves all together as one big unit.

The whole system is also turning like a huge wheel around its center. The sun and all the other stars are moving around the center of our Galaxy. Each one of these stars in this great system moves along its own path. At the outer edge of the wheel some stars are trailing along like the arms of a pinwheel. It takes a long time for the Galaxy to complete one turn. The sun takes about 200 million of our years to make one trip around the Galaxy. Some scientists think the Galaxy has made only about twelve turns since the earth was formed.

Other Galaxies

Astronomers think that there may be millions of other galaxies besides our own. These huge collections of stars are millions of light-years beyond our own Galaxy.

There is one galaxy which is visible to the naked eye from the northern part of our earth. If you look at the constellation Andromeda on a clear, moonless night, you may see a hazy spot of light near one of its stars. The stars in this constellation and in all the other constellations in the sky are part of our Milky Way system of stars. But when astronomers using telescopes studied this hazy spot of light in the constellation Andromeda, they found that it is not a star at all. It is not part of our Galaxy.



This tiny blur of light is actually a whole system of billions and billions of stars. It is over a million light-years away from our Galaxy.

The central portion of our Galaxy is hidden from us by huge clouds. But astronomers have made a study of the central portion of the galaxy in the constellation Andromeda. They think that our own Galaxy and the galaxy in Andromeda are similar in structure. In fact, they say that the Andromeda galaxy appears to us very much as the Milky Way system would appear to an observer out in space.

By the use of cameras and telescopes astronomers have been able to find many other galaxies beyond our own. Pictures of them, taken through telescopes, show that many are almost flat and round. This is much as we believe our Milky Way system to be. By studying these distant galaxies, we have been able to learn more about our own.

A Look at the Past

When you look at any of these distant galaxies, you are really looking across great spans of space. A million light-years is an enormous distance. You remember that light travels 6 trillion miles in one year. A million light-years would be a million times as far. Have you ever

stopped to think that when you look at such a distant object, you are also looking into the past?

The galaxy in the constellation Andromeda is the most distant object that you can see in the sky without the aid of a telescope. It is about 1,500,000 light-years away from the earth.

When you look at this galaxy, you are really looking back 1,500,000 years into the past. This is because the light that you see left the galaxy that many years ago.

In fact, you are not even looking at the galaxy where it is at the present time. You are looking at where it was 1,500,000 years ago. Remember that the light you see left the galaxy that long ago. The Andromeda galaxy has not been standing still. In those 1,500,000 years it has traveled billions of miles.

A portion of a cluster of galaxies

Clusters of Galaxies

Astronomers have found that every object in space seems to be part of a small group, which in turn belongs to a larger group. The sun and its family of planets are one such small group, which we call our solar system. We say that they form a group, or system, for several reasons. The sun is at the center of the group. The planets move around the sun.

The members of this group affect each other in many ways. If you have been swimming in the ocean, you have probably seen the tide "come in." The moon and the sun cause the tides that rise and fall in our oceans here on earth. This is one way in which our earth is affected by other members of the solar system.

All the parts of the system are in balance. Changes on the sun may bring about changes on the other members of the solar system. Finally, the sun is moving along in space, pulling the entire group of planets with it. The group we call the solar system is part of a much larger group, which we call the Galaxy.

But that is not all. Our Milky Way system belongs to a family of such galaxies. This family, or system, is sometimes called a cluster of galaxies. Such a system is, of course, so large that it is very difficult to

Galaxies vary in appearance

imagine. Galaxies millions of light-years apart may be members of the same cluster.

Some astronomers say that about nineteen galaxies make up the cluster to which the Milky Way system belongs. Several hundred other groups of galaxies have been found. Some of these contain hundreds or even thousands of galaxies each.

Finally, all the groups of galaxies thought of together make up the biggest group of all. We call this the universe.

We are not sure that this is the end of the story. Every time a larger telescope is made, scientists can see farther into space. With each new advance into space, galaxies have been found. Will this always be true? Shall we ever have a telescope large enough to show us an end to space?

Many scientists think it possible that we shall never see an end to space. Some galaxies may be so far away that their light will never reach us. If their light never reaches us, then we can never see them. No one really knows what kind of discoveries will be made about space in the future.

Many astronomers think that a long time ago the galaxies, including our own, were much closer together. It is as though there had been a huddle of galaxies. These men have set the time of the huddle at about 3 billion years ago. From that time to the present they tell us that the galaxies have been moving steadily apart.

There have been many explanations of how this might have been brought about. Many astronomers seem to think that about 3 billion years ago there was one big gaseous mass. In some way or other this gaseous mass exploded. From out of this explosive expansion the universe, as we know it, began. The turbulent masses of material gradually molded into the more regular forms we know as the stars and galaxies. This molding process is probably still taking place. It is thought that stars are still being molded from gas and dust formations.

According to this theory the material moved outward and away from the explosion. The galaxies started to spread and, to this very day, they are moving farther apart. Many astronomers believe that we are living in a universe which is growing bigger all the time.

LEARNING MORE ABOUT THE GALAXY

1. Luminous sky charts can be obtained from the National Equipment Service of the Girl Scouts. These charts will help you to locate the various stars in the summer and winter sky.

2. You might plan a trip to a planetarium or observatory if there is one near you.

3. If you enjoy taking pictures with a camera, you might try to photograph some of the stars. You can use any kind of camera. Place it on a box or other steady object and point it toward the stars. Open the shutter as wide as you can and leave the camera for several hours with the shutter opened. You can probably improve your results by experimenting. The streaks of light in your picture are called star trails. Can you explain them?

Light Energy All around Us

Light Energy and You

When did you get up today? Did you waken before sunrise or after? Perhaps you have never thought that most of us wait for sunlight before we get up in the morning. We plan a good part of our daily living according to when the sun rises and sets.

Some kind of light energy is with us almost all the time. Even when there is no sunlight shining on our part of the earth, we can usually push a switch and use electric lighting. In many towns there are street lamps, which supply light during the night. When there is not enough light, we can use flashlights, lanterns, candles, and many other things which provide light.

In fact, it is difficult to find a completely dark place even during the night. You might find a closet or some other such place in which it is quite dark. In a completely dark place you cannot see anything at all.

We Need Light Energy

It is through light energy that you are informed about many objects that are about you. Without light you would not be able to see anything. You would be cut off, in a sense, from the world around you. You would know of things only by touching, smelling, tasting, or hearing them. You would have a very different idea of what your world is like if there were no light energy to help you see.

If you have visited some of the large underground caverns near Carlsbad, New Mexico, you may have an idea of what it would be like in a completely dark world. No sunlight penetrates these dark, natural caverns. Electric lamps light the way as you descend into the dark depths.

On some of the trips through the caverns the guides tell you to sit down quietly. Then the lights are turned off. If everyone stays very still, you cannot be sure that anyone is near you. You are not able to see anything.

In our everyday living, light from the sun or from some other source is with us practically all the time. We have taken light for granted. Think how difficult and different your life might be if you did not have any light energy to use!

Worshiping the sun

Light and Early Man

Our earth was not always lighted at night the way it is now. There was a time when there were no street lamps anywhere on our earth. Once no one had a flashlight or lantern or even a burning torch to light his way at night or along a footpath in a dark wood. The only source of light was the sun.

Long ago it was only during the daylight hours that there was enough light for a person to see and move about easily. At night men must have huddled together until dawn. They had a great deal to be afraid of. Since men could not move around in the dark as well as the wild animals, they were at a disadvantage. They could not protect themselves as well at night as they could during daylight.

Sunlight must have been very welcome to these early people. The light from the sun made it possible for them to see the world around them. During the daylight hours men could be warned of danger before it was upon them.

Primitive people made many great discoveries. Probably one of the greatest discoveries was the use of

fire. At first fire may have come from wood which had been set burning by lightning. Long ago, people probably did not know how to start a fire themselves. So when a fire was set, it was very important for them to keep the fire burning.

Fire and Light

As man learned more about fire, he was able to use it for many purposes. He discovered that he could use fire to cook his food and to keep himself and his family warm. He also discovered that he could use the light from a fire.

At first people may have noticed that the light from a fire helped them to see objects around their camp at night. If they moved away from the light of the fire, it would be very dark, and they would not be able to see. Perhaps at some time someone picked up a stick which was burning at one end and carried it to light his way as he moved away from the fire at night.

When man learned that he could carry a burning torch to light his way, he had made a big step forward. Now he had a source of light which he could carry with him.

The discovery that a man could carry a torch to light his way brought new difficulties. When walking through a field or forest with a torch, someone may accidentally have started a fire. Such a fire

may have destroyed his home. Perhaps some members of his family lost their lives.

Each new discovery has probably always brought new problems. Certainly, as man learned to use the fire of a torch for light, he had many problems to solve. Some of these were solved by discovering other ways of using fire to produce light.

What Is Light?

For many centuries light was produced by the burning of some material such as oil, wax, or gas. To use these materials, such things as oil lamps, candles, and gas lamps were made. Before man was able to use other methods of lighting, he had to find out something about light itself and how it is produced.

Heating Produces Light

Perhaps in your home you have an open fireplace or a furnace in which wood or coal is burned. Many people use an iron poker to turn or

poke the burning material in a fireplace or a furnace. If an iron poker is left in the fire for some time, it becomes red and begins to glow. We say it is red hot.

You can heat something in your classroom till it is red hot. First, push one end of a small needle into a cork. Then by holding the cork, you can place the needle in a candle flame.

Notice the part of the needle which has been placed in the flame. When the needle has been heated for a short time, it will begin to give off a reddish glow. The reddish light will be seen easily as the needle receives more and more heat.

The needle must be heated to a certain temperature before it will begin to glow. If the needle is taken out of the flame, it stops glowing, but it is still too hot to handle. It is a good idea to cool such a hot needle by placing it in a pan of cold water.

High Temperatures and Light

As you may know, it used to be a common sight to see a blacksmith working with iron. First, he heated a piece of iron in a fire and then shaped the iron to make something from it. In order to shape the iron properly, he had to heat it to a high temperature.

You may think it would be difficult to know the temperature of a piece of iron as it is held in a fire. However, blacksmiths found an easy way to tell if the iron had been heated to the proper temperature.

Blacksmiths observed the color of iron as it was heated in their fires.

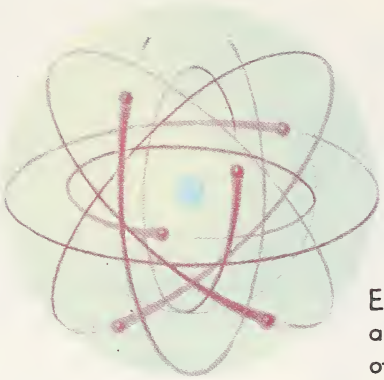
They noticed that after being in the fire for a while, iron began to give off a reddish glow. Then as they continued to heat the iron, they saw that it changed color still more. Its color changed from red to yellow. Before the iron gave off a yellowish light, it had to be heated to a higher temperature than that at which its light was red.

If a blacksmith had a very hot fire, he was able to heat the iron even more. He noticed that when he heated the hot, yellowish iron to a still higher temperature, it became white. It took a very hot fire to make the iron give off a white glow.

By observing the color of the iron, a blacksmith was able to tell how hot it was. He knew by the color of the light when the iron was heated to the proper temperature.

Men and women who studied this were puzzled about it for a long time. They asked themselves many questions. Why should a piece of iron give off light when it is heated? Why should the color of the light change as the iron becomes hotter?

These people developed many theories as answers to these questions. A theory is like a story which men invent to help explain what they see happen. Theories are usually not complete explanations.



Electrons spinning around the center of an atom of carbon

Light from Atoms

One explanation of why iron glows when heated is based on a theory about atoms. As you may remember, everything on the earth or in the sky is made of atoms. A small piece of iron is made of millions of atoms. A needle or a pencil is also made of millions of atoms. In fact, you are made of atoms, too.

Scientists tell us that the outer parts of atoms, called electrons, keep revolving very rapidly around the center of each atom. This is rather hard to imagine. Even with the most powerful microscope no man has ever been able to see what an atom or an electron looks like. Maybe no one ever will. But this theory helps to explain certain happenings which seem to be explained in no other way as yet.

This theory helps to explain why iron changes color as it is heated. As the electrons of the iron atoms receive more heat energy, they begin moving faster and faster. The more heat the electrons receive, the faster they move. The electrons now have more energy than they had before. It is believed that the electrons give off this energy as light.

When the electrons of the iron atoms have received only a certain amount of heat, they give off red light. If more heat energy is supplied to the electrons, they move faster and their light is yellowish. It takes much more heat energy for the electrons to give off white light. Electrons which glow with a white light are moving faster and have more energy than electrons which give off yellow light or red light.

Heating Metals

When a blacksmith heats a piece of iron, he is heating a piece of metal. Tin, zinc, and copper are also metals. You probably know of many more. You might make a list of as many metals as you can think of. We have started a list on this page. It would be a good idea to check to make sure that each thing on your list is really a metal.

List of metals	
Iron	
Tin	
Zinc	
Copper	

Man has discovered many different ways of heating metals. We have read how a metal can be heated by placing it in a flame. What would you suggest as another way of heating a metal?

The boy and girl in the picture on this page are heating a metal in another way. They are using electrical energy to heat a wire. If you wish to try their experiment, you will need a dry cell and a piece of insulated copper wire.

Connect an end of the wire to one post of the dry cell. Then hold the free end of wire against the other post of the dry cell. In a short time the wire will become hot. It will feel

warm to your hand, even though it is insulated. Electrical energy heats wire as it moves through it. It will heat a piece of wire so much that you cannot hold it. The wire will begin to cool as soon as you have disconnected it.

Some boys and girls tried an experiment to see if it was possible to make metal give off light without using fire to heat it. Instead of a flame they used electrical energy to provide heat. They experimented with a small, thin piece of iron wire. The picture on this page shows how they did their experiment. You might try this experiment, too.

You will need two pieces of insulated copper wire, one short, very thin piece of uninsulated iron wire, and a dry cell. First, fasten the wires together by twisting a piece of copper wire to each end of the iron wire. This will make one long strand of wire, consisting of the three pieces of wire fastened together.

Now connect one end of this strand to the dry cell. Hold the other end against the second post of the dry cell. In a short time all three pieces of wire will begin to get hot. But the iron wire will become much hotter than the copper wires.

This is partly because the iron wire is not insulated. It is also so thin that it is hard for electrical

energy to travel along it. The energy can travel along the thicker, copper wire more easily.

The iron wire becomes so hot that it will begin to glow. Electrical energy will make the iron wire give off light as it is heated.

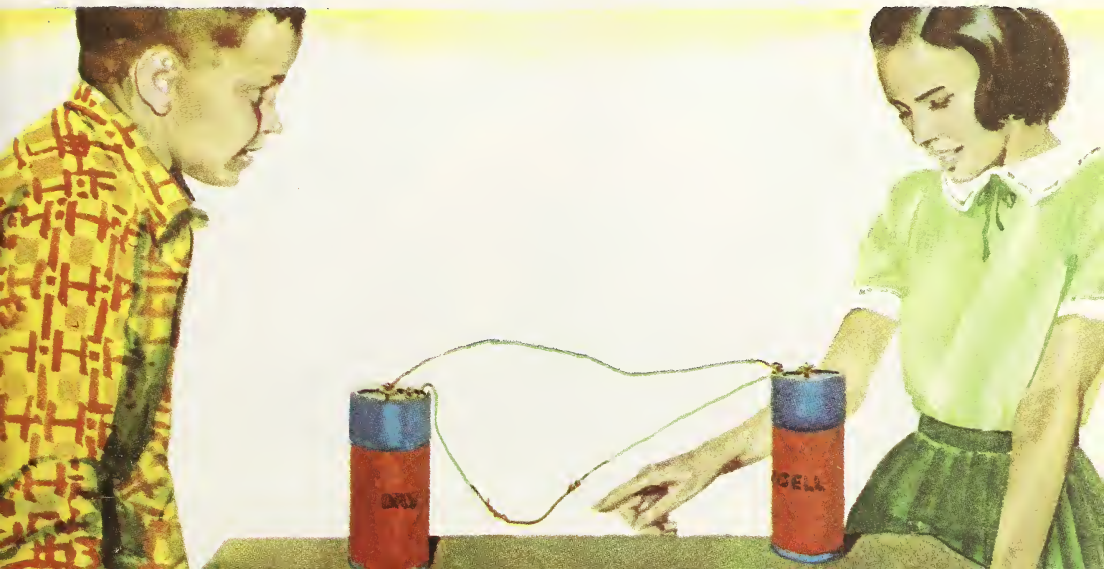
Heating Metals for Light

When a metal receives enough heat energy, some of the energy is changed into light. Each one of the metals on the list which you made will give off light when heated to a high temperature. This is not true of all things. Many things will burn when brought near a flame. However, it is possible to heat metals to very high temperatures without burning them. All metals begin to glow when they receive enough heat.

It is believed that the electrons of atoms of zinc, tin, copper, and other metals move in much the same way that electrons of iron atoms do. As their heat energy becomes greater, they too speed up and move faster and faster. Their additional energy is given off in the form of light.

You have done an experiment in which you heated a small piece of iron wire until it became so hot that it glowed. It would be possible to use a very thin, short piece of uninsulated copper wire in place of the iron wire. You might also want to use two dry cells, instead of one, for better results.

Electrical energy changes to heat energy in the wire. The atoms of the metal of which the wire is made become heated. When the electrons

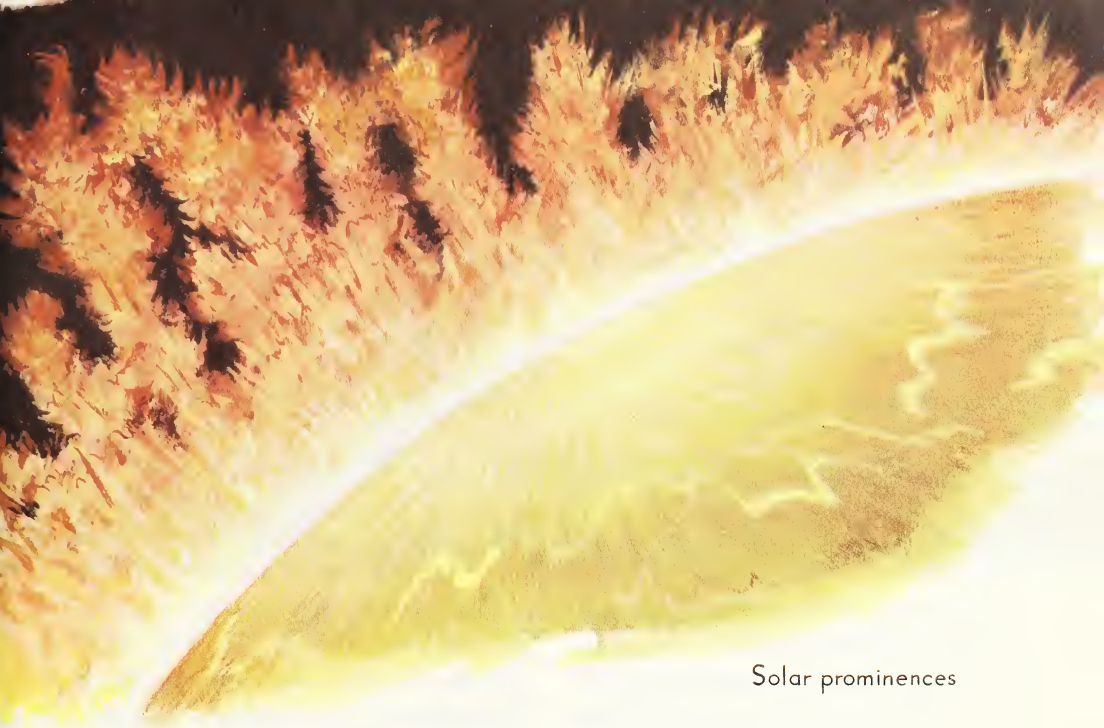


of the atoms receive a certain amount of heat energy, they give off light. Electrical energy is really being changed to light energy. This is the same kind of thing which happens in the electric-light bulbs which you use in your home.

It is interesting to examine electric-light bulbs. There are bulbs of many different sizes and shapes. Many, such as the small bulbs used in flashlights, are made of clear glass. If you examine such a bulb, you will notice a very thin piece of wire. The thin piece of wire is made from a metal called tungsten.

Electrical energy is changed to heat energy in the tungsten wire of the light bulb. The heat energy is then changed to light energy. This happens when the atoms of tungsten are heated to a certain temperature.

Men who study about metals tell us that the color of the light is different for different metals. It has been discovered that each metal gives off its own particular colors when heated to very high temperatures. Scientists have found that this is very useful information. They can place a bit of metal in a flame and notice the color of the light it gives off. The color of the light will help them to know what the metal is.



Solar prominences

Light from the Sun

We have read how important sunlight was to early men. They depended on the sun as their only source of light. Even today our biggest source of light energy is the sun. Energy from the sun is just as necessary to us as it was to people of long ago. Of course we have come to realize its importance in ways not known by early men.

We know that the energy from the sun is necessary to green plants. The plants could not make food if they were not bathed in sunlight. Without plants we would lack food. In fact, we could not live at all without green plants.

Besides providing us with food, sunlight is important to us in many other ways. You might make a list of ways in which sunlight is valuable. It will help you to make your list if you discuss it with your friends.

How Is Sunlight Produced?

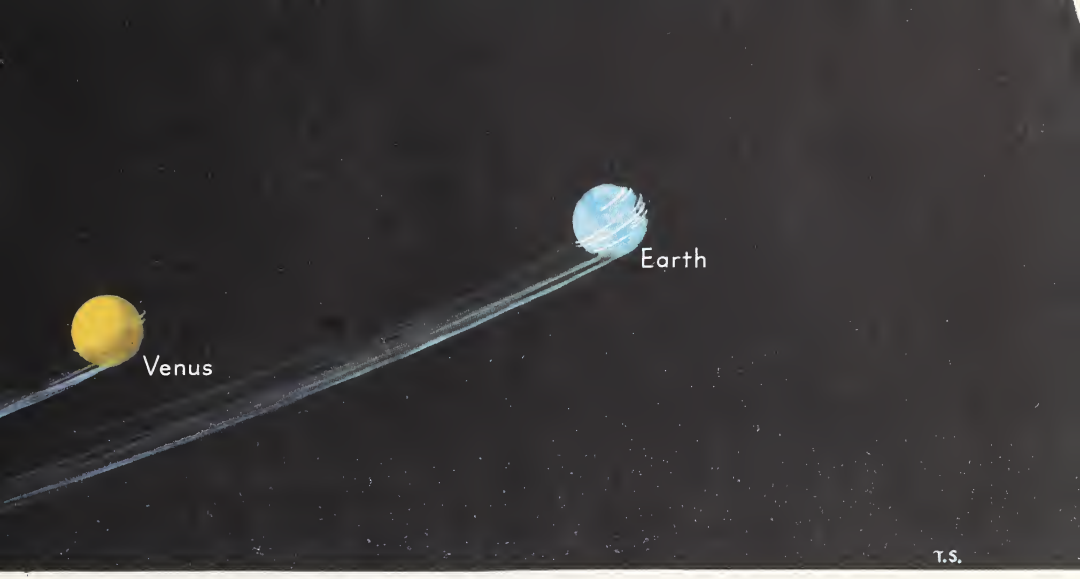
Think of the sun—that great generator of energy! What is it that produces the energy of the sun? How does the sun send out the great amounts of light and heat that reach our earth each day?

Men have probably always wondered what is happening inside the sun. We know that something must be going on which produces all that light. But what is it? It has been only a very short time since we began to understand much about the energy of the sun. About the year 1940 men who study the sun made some discoveries. These discoveries helped them understand how the sun's energy is produced.

These men found out that most of the sun, or about 90 per cent of it, is made of hydrogen gas. Atoms of hydrogen gas in the sun join together, and a new gas is formed. When four atoms of hydrogen gas combine, they form an atom of helium gas. Great amounts of energy are released when this happens.

All the atoms of the sun are heated to very high temperatures. The atoms are heated by the energy which is released when helium gas is made from hydrogen gas.

In the sun, in addition to the atoms of hydrogen and helium, there are atoms of other materials, such as iron, oxygen, carbon, and many others. As you know, the electrons



of atoms of metals and of some gases give off light energy when heated to high temperatures. The electrons of the heated atoms in the sun give off light energy in the same way.

Sunlight through Space

Light energy from the sun strikes our earth. It comes to us through space. The sunlight travels about 93 million miles from the sun to our earth.

Have you ever thought what it would be like out in space? Imagine that we went out in space, far beyond the earth. Let's even go out beyond our moon. What would it be like in outer space between our earth and the sun?

Most of this space is black. From outer space we would be able to see the sun and the other stars shining in the sky. But the space around us would not be light. This seems strange, doesn't it? If outer space is black, how does the light energy from the sun reach our earth?

No one has yet been far out in space to see what it is really like. However, from their studies scientists are able to explain how it must be. Light energy passes through space between our earth and the sun. We can see the light from the sun when it reaches our eyes, but it cannot be seen as it passes through space. There are many small par-

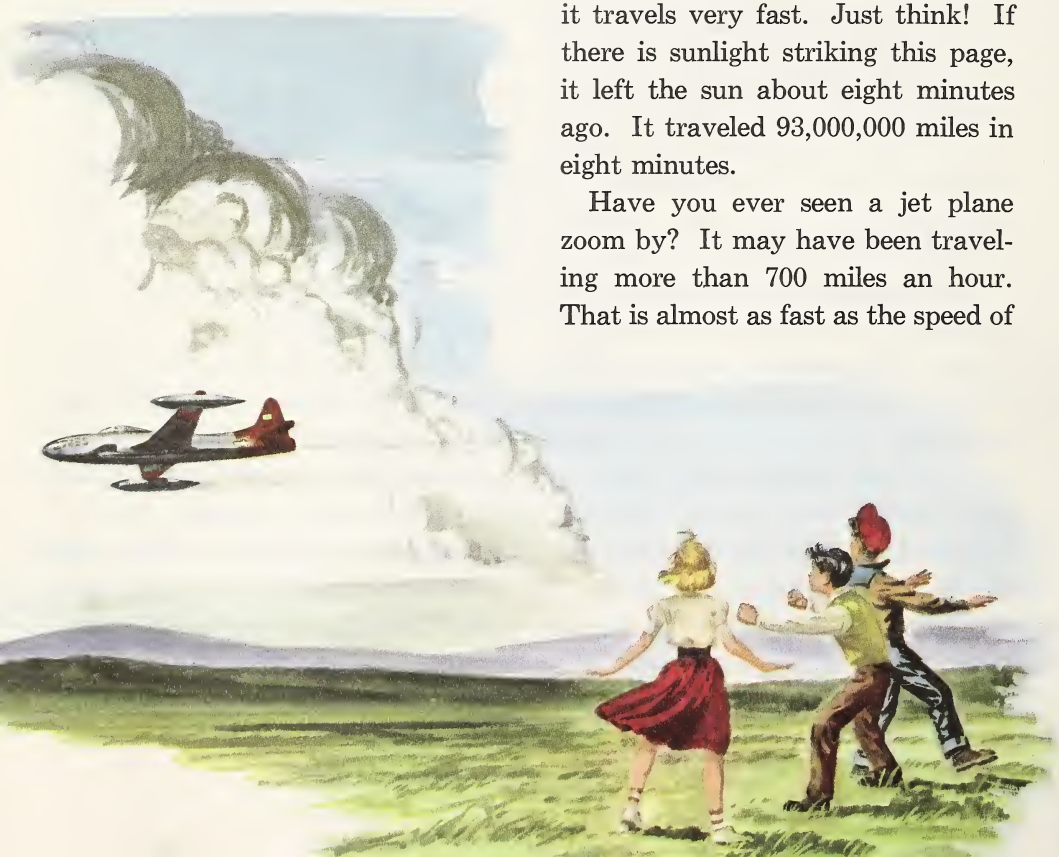
ticles in the earth's atmosphere. When the sun's energy reaches our atmosphere, it strikes these particles, and we see its light. There are few objects in the way of light energy as it travels from the sun to the earth. Most of outer space is thought to be empty. Since there are practically no particles for the energy to strike, outer space is black.

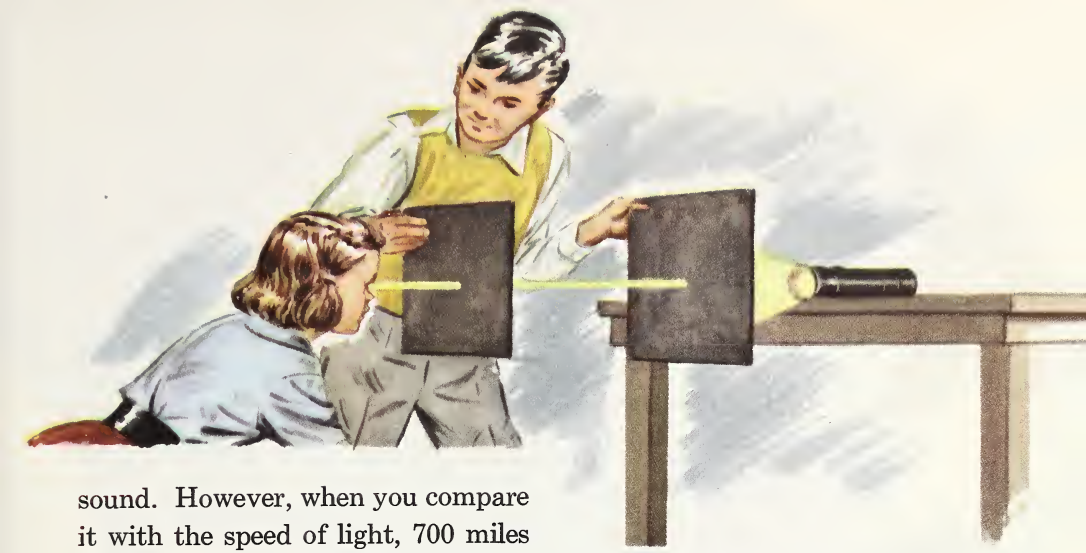
Experimenting with Light

We often hear people say that light strikes an object. They are right. Light energy strikes an object with a force that can be measured. Of course the force with which it strikes is very, very small, but scientists have measured the pressure of sunlight.

Part of the force with which light strikes an object is due to the speed of light. Light energy is moving and it travels very fast. Just think! If there is sunlight striking this page, it left the sun about eight minutes ago. It traveled 93,000,000 miles in eight minutes.

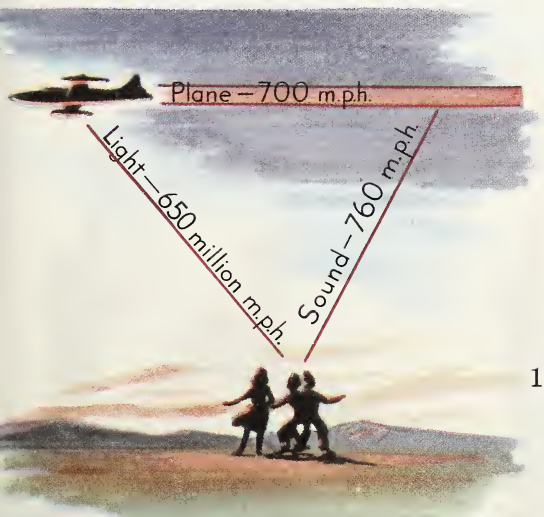
Have you ever seen a jet plane zoom by? It may have been traveling more than 700 miles an hour. That is almost as fast as the speed of





sound. However, when you compare it with the speed of light, 700 miles an hour is not very fast. Light travels 186,000 miles in one second. This is more than 650 million miles an hour.

You are able to see a jet plane, even though it is flying rapidly, because it moves much slower than the speed of light. The light can travel to your eyes from the plane faster than the plane can move.



The Movement of Light

We know that light energy travels in straight lines. The boy and girl in the picture above are doing an experiment which you might try. It may help you to see how light moves.

You will need a flashlight and two pieces of cardboard, each about 12 inches square. First, cut a small, round hole about the size of a dime in the center of each card.

Then place the flashlight on the table as you see in the picture. The boy in the picture is holding the cards for the girl. He is holding a card about 8 inches from one of her eyes. The other card is held between the first card and the flashlight.

First, the cards should be held so that the two holes and the light are in a straight line. Then by looking through the two holes, you can see the light.

Now move one of the cards about 2 inches to the right. Can you still see the light? You will not be able to see the beam of light, because the holes are no longer in line with the light. Light energy cannot bend around the cardboard.

Light Changes Direction

When light strikes a mirror, wall, or other object, some of the light usually changes its direction. But the light energy continues to travel in a straight line, even though it has changed direction.

Here is an experiment which will help you to understand how a beam of light changes direction: You will need a beam of sunlight which is coming through a window and striking the floor. Place a pocket mirror in this shaft of sunlight so that some of the sunlight strikes the mirror instead of the floor. Now there is a bright spot of light on the ceiling. Part of the sunlight is striking the ceiling instead of the floor.

A beam of light changes direction when it strikes the surface of a mirror. By moving the mirror in the sunlight, you can control the spot of light. You can make it shine on the ceiling or on the wall.

In going through air about us, light changes direction many times. You probably do not notice that light is changing direction, but it is happening all around you right now.

Light in a Hallway

We have read that light travels in straight lines. If it strikes an object in its path, the light may change direction.

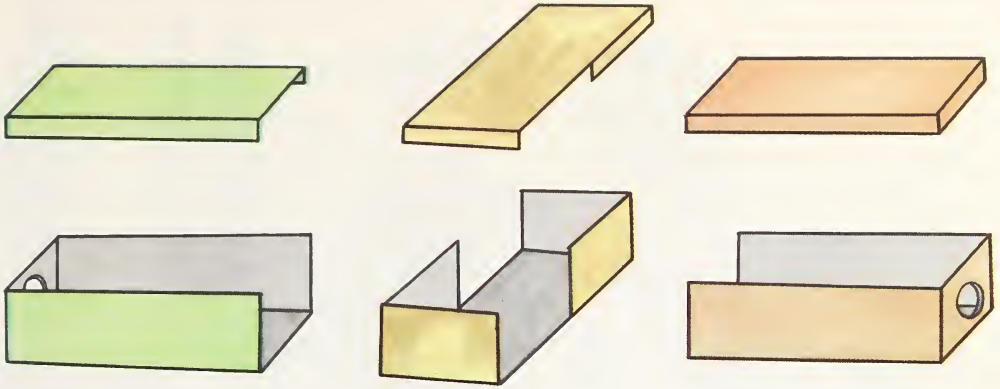
Let's see how this makes a difference in the position in which a light should be placed in the hallway you see pictured above. As you notice, there is only one light. You can see where it is placed now. Some boys and girls want to decide where it should be placed to light as much of the hallway as possible.

The boys and girls are experimenting to see how much light they can see at each position in the hallway. See where one girl is standing. How much light can she see when

she stands in that position? The light comes straight down the hallway. The girl can see a lot of light because the light travels in a straight line to where she is standing.

But what about the boy who is standing in the next position in the hallway? How much light does he see? The light travels in a straight line to where the girl is standing. When it strikes the wall back of the girl, it changes direction. Some of it strikes the other walls. And again the light changes direction. Now some of it is directed toward the boy. He is able to see some of the light.

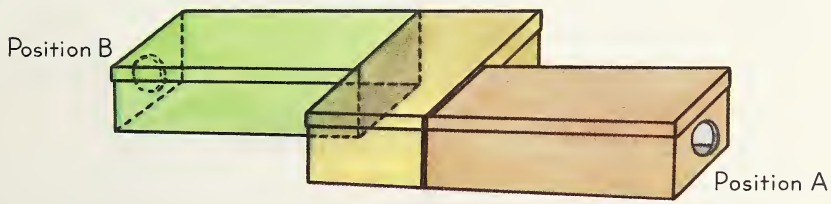
Do you think that the girl sitting at the far end of the hallway can see any light? You might try an ex-



periment to find out. You will need three shoe boxes and a flashlight. By cutting holes in the boxes and joining them together as you see in the pictures on this page, you can make a miniature hallway.

Place the flashlight in the position marked *A* in the picture below. Then look through the boxes from position *B*, which corresponds to the position in the hallway where the girl is seated. As you look down this part of the miniature hallway, how much light can you see?

You can use your arrangement of shoe boxes to test the amount of light that the other two children are able to see from their positions in the hallway. You remember that the boys and girls in the hallway started their experiment in order to find out where to place the light. They wanted as much of the hallway as possible to be lighted. Where do you think that the boys and girls finally decided that the light should be placed? Use your arrangement of shoe boxes to test your answer.



Let's Look at Colors

You already know that to see an object, you need light. When it is completely dark, you can see no objects at all nor any colors. When there is enough light, you can see colors of every sort.

Perhaps you have seen a rainbow in the sky. The spread of color is very beautiful. But look around! There's a great variety of color all about you. Probably there are many different shades of green, blue, and red. There must be shades of any color that you can name.

A Bundle of Light

Here is something you have probably seen happen many times: sunlight coming through a window may strike a piece of cut glass. In the picture below look at the cut-glass chandelier and the arrangement of colors which are striking the floor and the wall. You can see violet, blue, green, yellow, orange, and red. If the cut glass starts swinging in the sunlight, then the colors will also swing back and forth. Something happens to sunlight as it comes through a piece of cut glass.

You might say that a beam of sunlight is really a bundle of light. It is made up of many different colors of light. When sunlight strikes a piece of cut glass, the colors in the bundle of light change direction. As they go through the glass, they all change in the same direction,

but some change more than others. Violet changes direction more than the other colors do. Blue changes direction more than green. Green changes more than yellow does, and yellow more than orange. Red light changes direction less than any of the others. In this way the bundle of light is separated into its various colors.

The different parts of sunlight may be separated at other times also. We see rainbows in the sky because little drops of water change the direction of the light. Some parts of the light change direction more than other parts. This causes the various colors in sunlight to be spread out across the sky.

Where Do Colors Come From?

The color of objects depends upon the light that strikes them. The following experiment will help you to see this. You will need a green crayon and a large piece of bright-red cellophane.

First, color a large, green spot on a white piece of paper. Now place the paper in a beam of sunlight. Fold a piece of red cellophane and hold it so that the sunlight shines through several thicknesses of cellophane before striking the paper. Look at the spot which you have colored. It no longer looks green. It seems to be black.

When sunlight shines on red cellophane, only the red part of the sunlight shines through. The red light shines on the spot which you colored green. But there is none of the color green in the red light. So the spot that you colored no longer looks green, but black.

When an object looks red or blue or purple or any other color, we say that it reflects that particular color. You know that light can change direction. When light strikes a colored object, the object may send back only a small portion of the light. A red dish looks red because it sends back only the red part of the light which strikes it. If there were no red in the light, the dish would look black. It would send back hardly any light at all.

How do we see colors in our homes at night when there is no sunlight? The light which we use at night is given off by electric-light bulbs. If we see colors, they must be in the light from our lamps.

You might take a piece of cut glass and shine an electric light through it. You will find that you can see many colors. You will get better results if you use a flashlight and a piece of cut glass in a dark room.

There are many different colors in the bundle of light coming from an electric light. When you look at a blue dress by electric light, you can see the color blue because there is blue in the light coming from the electric-light bulb. The dress might look a different shade of blue in the sunlight. There is usually a different amount of blue in electric light than there is in sunlight.

You might try changing the color of light coming from a flashlight, much as you changed the color of sunlight, by experimenting with a piece of red cellophane. First, cover a flashlight with several thicknesses of red cellophane. Then darken the room and shine the red light on objects of various colors. Do you see how the colors change?

Your experiments with a piece of cut glass showed you that there are many different colors in the light from the sun. There are many different colors in the light made by electricity too.

Color adds to the beauty of the world. The colors of the trees, of the landscape, and of the clothes we wear make the world a much more enjoyable place. Colors are part of the light energy which reaches the earth each day from our sun.

LEARNING MORE ABOUT LIGHT

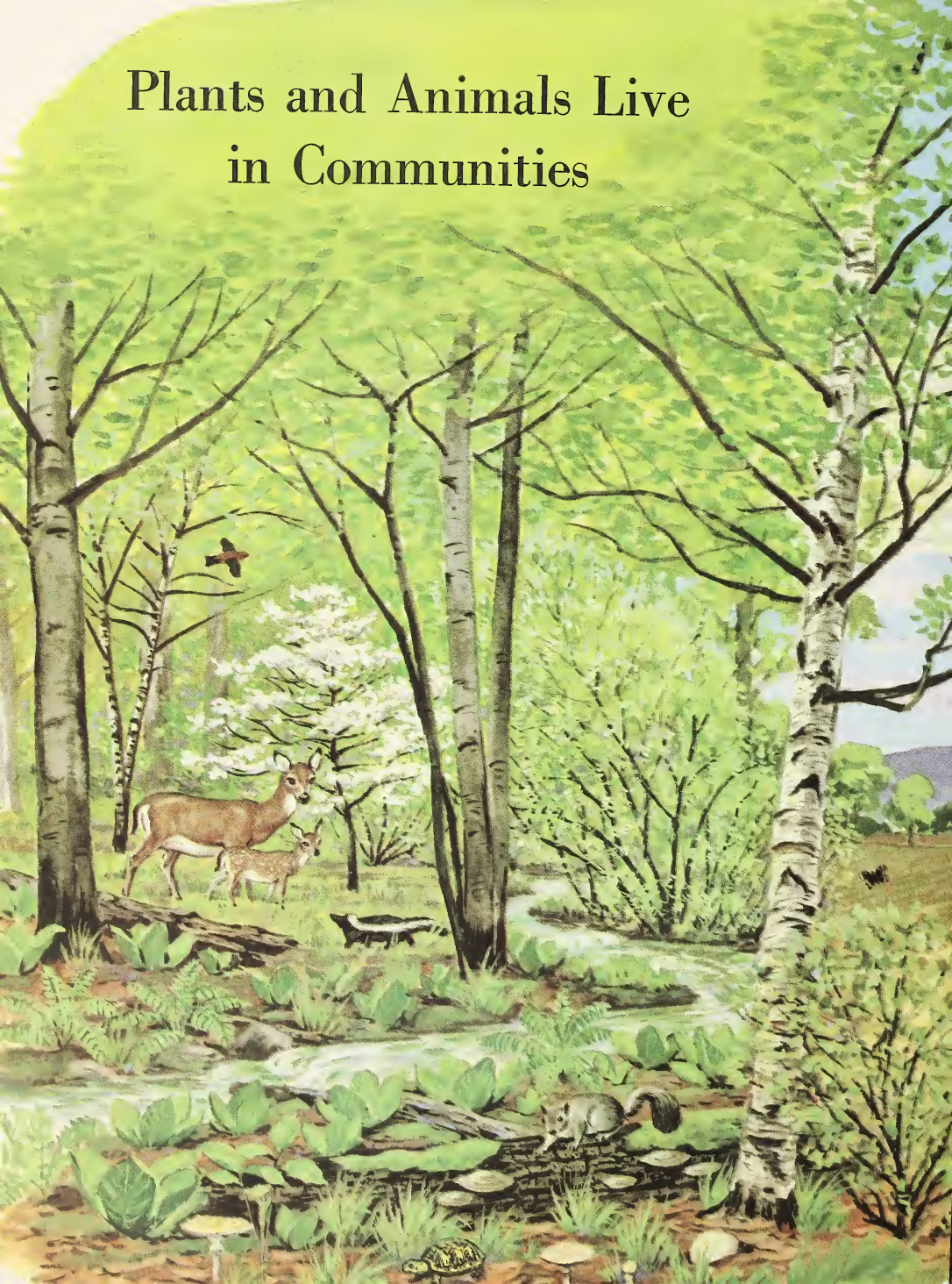
1. Place a pencil in a glass of water. Look at the pencil through the side of the glass. The pencil will appear to be broken at the place where the air and the water come together. What do you think is the reason for this?

2. When the sunlight strikes a spray of water from a lawn sprinkler, you may see a rainbow in the spray. How do you think the rainbow is formed? How would you explain a rainbow in the sky?

3. Place a piece of heavy colored paper behind a piece of window glass. You will be able to use the glass with the paper behind it as a mirror. Why is this so?

4. A man bought a blue suit. It was during the evening and the store was well lighted by electric lights. He liked the blue color of the suit. But when he looked at the suit in sunlight, he said it looked like a brighter shade of blue. How would you explain this?

Plants and Animals Live in Communities

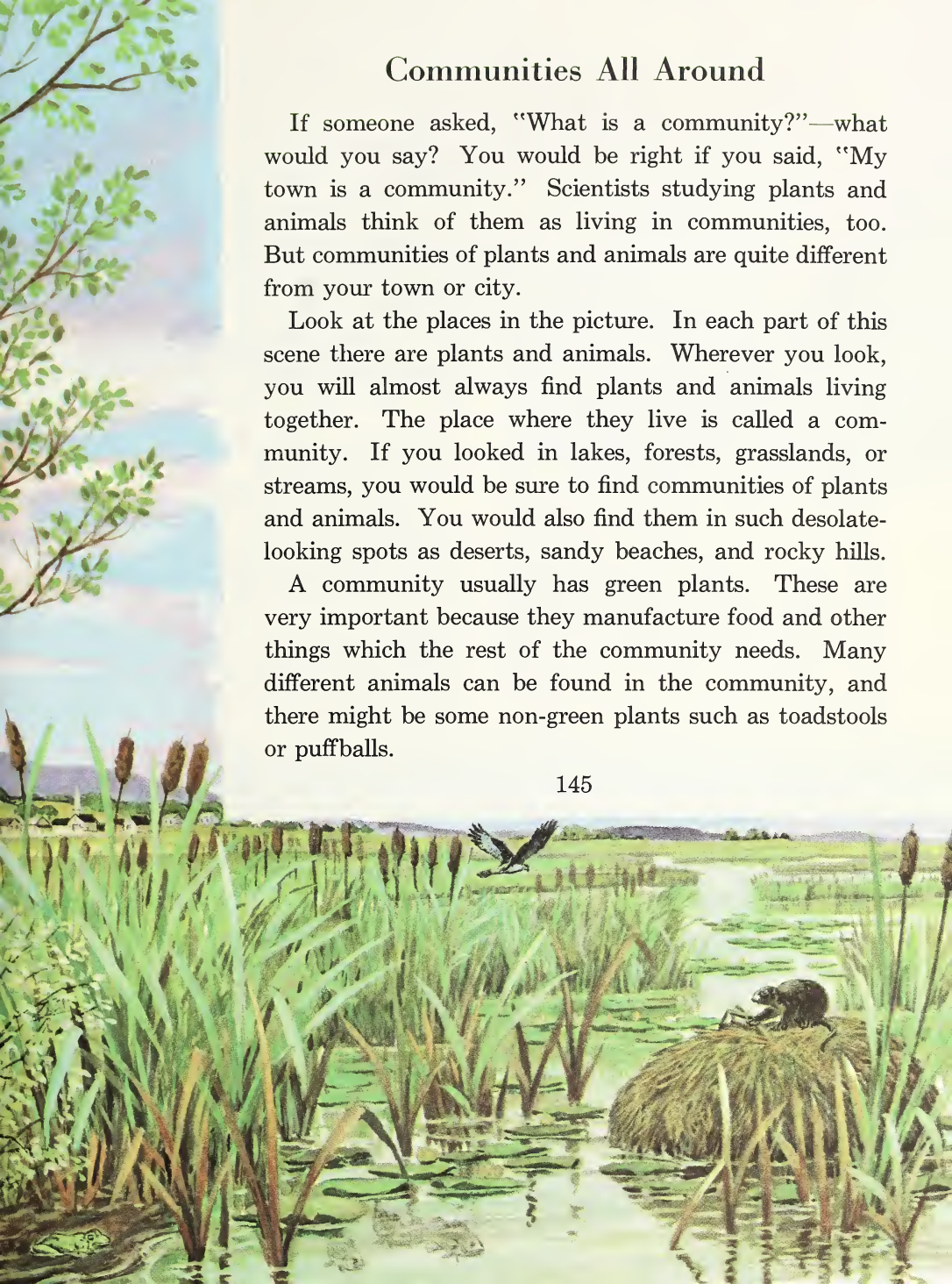


Communities All Around

If someone asked, "What is a community?"—what would you say? You would be right if you said, "My town is a community." Scientists studying plants and animals think of them as living in communities, too. But communities of plants and animals are quite different from your town or city.

Look at the places in the picture. In each part of this scene there are plants and animals. Wherever you look, you will almost always find plants and animals living together. The place where they live is called a community. If you looked in lakes, forests, grasslands, or streams, you would be sure to find communities of plants and animals. You would also find them in such desolate-looking spots as deserts, sandy beaches, and rocky hills.

A community usually has green plants. These are very important because they manufacture food and other things which the rest of the community needs. Many different animals can be found in the community, and there might be some non-green plants such as toadstools or puffballs.



A group of plants and animals living together can usually find everything necessary to keep them alive right in their community. There is, however, a very delicate balance between them. If something happens to any part, the rest of the community is also affected.

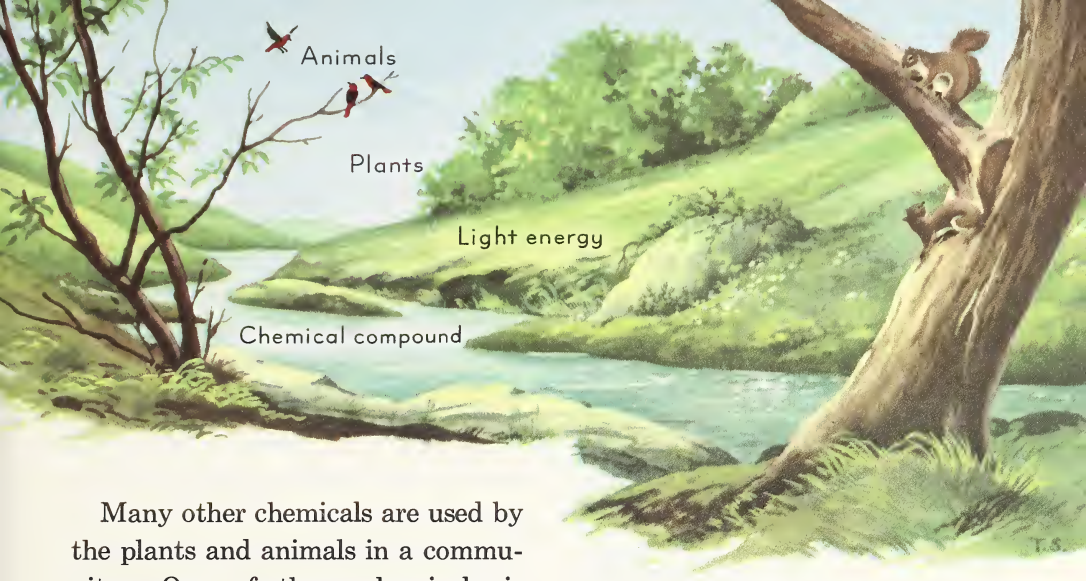
Balance in the Community

As you know, animals depend either directly or indirectly upon green plants for food. In the arctic there are animals known as caribou. The caribou eat green plants such as grasses and dwarf willows. The caribou, in turn, are hunted as food by the wolves that also live in the arctic region. The wolves depend on the caribou and the caribou depend on green plants. So you see, the wolves depend indirectly upon green plants for food.

Green plants need energy from the sun to produce the plant material which animals use as food. So when we think of a community, we must think of the sun as well as of the plants and animals.

Plants also need certain other materials found in a community. These materials are called chemicals. Two of the most important of these chemicals are used by plants in food-making. You know these chemicals as water and carbon dioxide.

Caribou



Many other chemicals are used by the plants and animals in a community. One of these chemicals is oxygen. Without a continual supply of oxygen no animal would be able to live.

Chemicals are a very important part of any community, but a community depends upon all its parts. Most communities consist of plants, animals, chemicals, and energy from the sun.

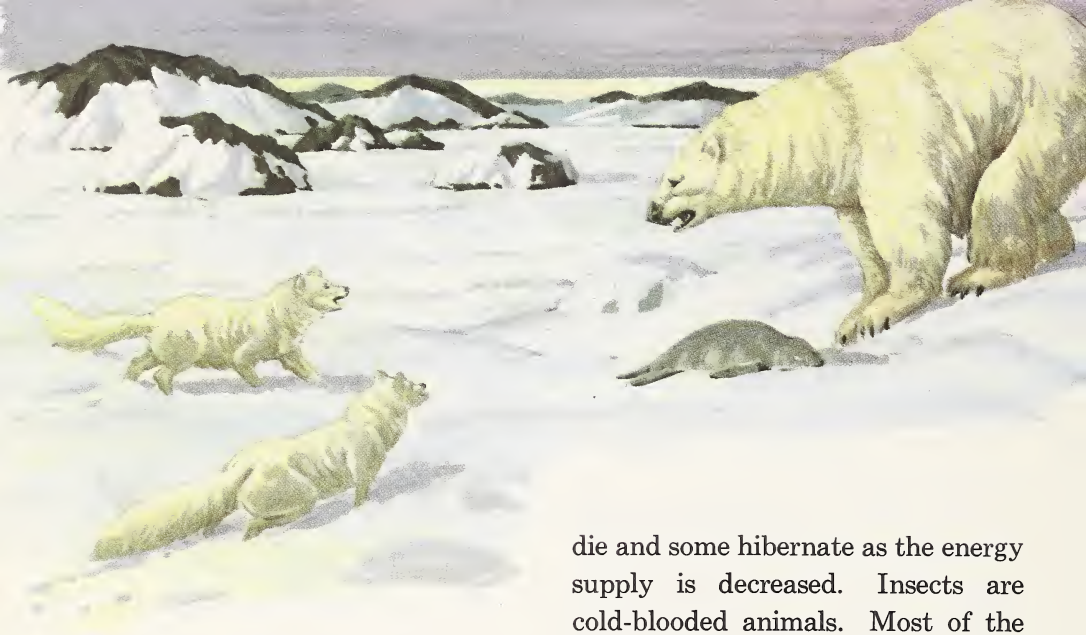
Energy and the Community

Energy from the sun becomes a real part of the community. It cannot be separated from the community without disturbing the community balance.

Most of the energy reaching our earth and all its many communities comes as light energy. Once it reaches the community, some of it is actually used as light energy. But most of it is changed into heat energy.

Only a small portion of the light absorbed by plants is used in food-making. It is changed by plants to chemical energy. The rest is changed into heat energy and is given off to the air, land, and water of the community.

Animals eat plants as food, and much of the chemical energy in the plants is then changed to heat energy. You might think of this process as somewhat like a "chain" of energy. This chain of energy extends from sun, to plant, to animal.



At each point in the chain most of the energy is changed into heat. In this way light becomes a part of the community. Without this energy there could be no life.

Changes in the energy supply of a community affect the whole community. On the island of Spitzbergen, off the coast of Norway, foxes are able to feed on birds, insects, and plants during summer. Summer is a time of plentiful energy supply in the community.

But as winter approaches, there is a decrease in the energy supply of the community, and most of the birds begin to leave. Some insects die and some hibernate as the energy supply is decreased. Insects are cold-blooded animals. Most of the plants go into a resting stage and do not produce food during the winter.

During the time of decreased energy supply the foxes must find ways of keeping themselves alive. They move out onto the frozen sea. On the ice they search for the dead bodies of seals, which are the remains of the unfinished meals of polar bears.

The ways in which plants and animals live are changed by changes in energy. The growth of plants is affected, and any changes in plant growth affect the food supply of animals. There is a constant change in the life of a community as its energy supply increases or decreases.

Temperature and the Community

You might think that the energy supply of a community depends only on the amount of energy which reaches it from the sun. But the energy supply also depends on the community as well.

Here is an experiment which will show that the community affects its own energy supply: You will need two boxes, a large pail, and three outdoor thermometers. Fill one box with sand. Place soil covered with grass in the other and fill the pail with water. Place a thermometer in each of the containers, just as you see in the picture. In each case the top of the thermometer bulb should be at least $\frac{1}{4}$ inch below the surface.

On a day when the temperature of the air is well above freezing, place the three containers outside. They should be placed so that they will be exposed to the sun during the day. It will help to have them beside each other so that they receive the same amount of sunlight.

Leave the containers overnight. As early as possible in the morning take a reading for each thermometer. Continue to record the temperature of the sand, soil covered with grass, and water every hour throughout the day.

When your record is complete, compare the temperatures. Does the temperature for each container stay the same as when you took your first

reading? Compare the differences in the way the three areas heated up during the day.

You probably will find that the sandy area heated up much faster than the grassy or the water area. Your record will probably also show that the sandy area was heated to a much higher temperature than either of the other two. Does the water heat up more slowly than the other two areas?

Again allow the containers to remain in the same position overnight. Repeat the experiment. Which container is at the lowest temperature in the morning? Which container goes through the greatest temperature change during the day? Which changes the least?

In all three cases there is a temperature change during the day. The sand, the soil with plants, and the water all heat up. Light energy becomes a part of each community by being changed to heat energy. The results of the experiment seem to show, however, that temperature changes less in water than on land. When soil has some kind of plant life, it does not heat up as fast as when it is barren.

This means that if the community is a sandy desert, we can expect great changes in temperature during the day. There will also be a great difference between day and night temperatures. On the other hand,

Communities affect their own energy supply

Broad-leaved forest

Prairie

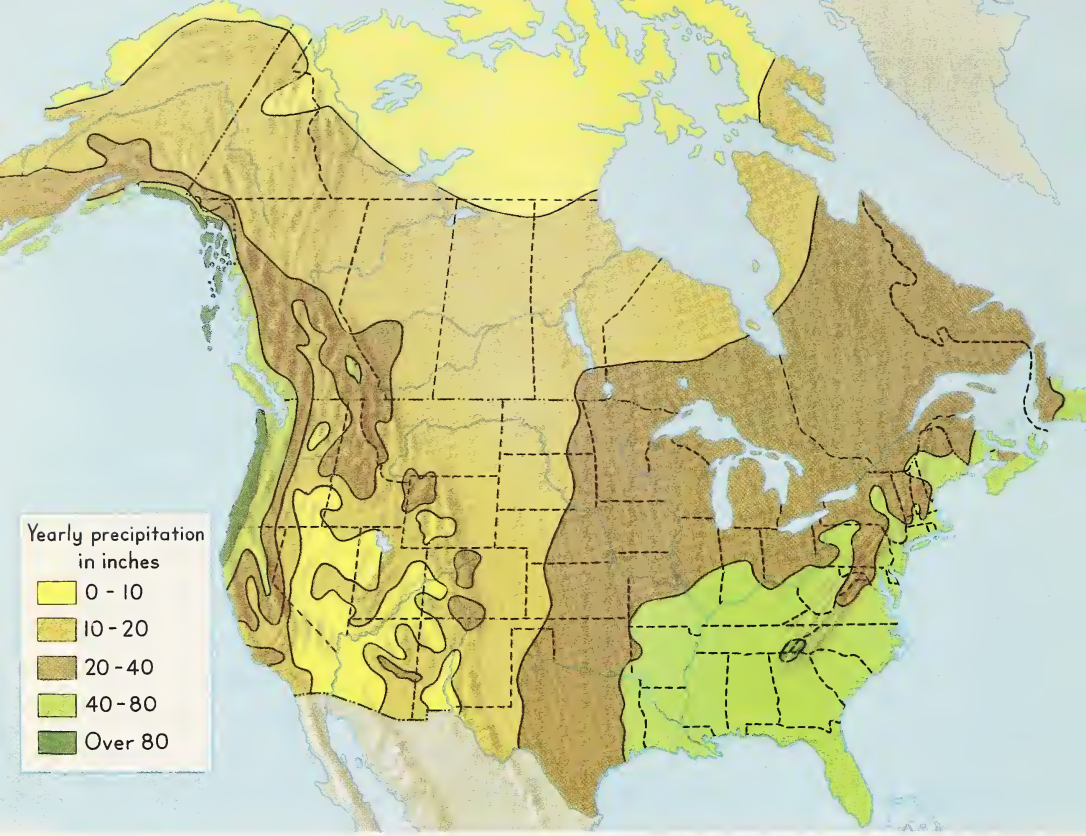
water communities will be slow to warm up and slow to cool off. The soil community with plant cover will not lose its heat as fast as bare soil.

Water and the Community

In some parts of the United States and Canada you will find forests as the plant cover for the land. The eastern part of North America is an ideal location for the growth of broad-leaved forests. When the rainfall is evenly distributed, there is always a good supply of water for the trees. Such forests can be found in the Appalachian Mountains in the eastern part of the United States. They can be found in Wisconsin, Minnesota and southeastern Canada as well.

In the prairie regions you will find tall, bluestem grass. The change in plant covering from trees to grass is brought about by a decrease in rainfall. The grass grows where there is not enough water for tree growth. In areas where the rainfall is even less there may be only enough water to allow short grasses to grow.

The kind of plant cover we find growing on soil depends partly on the amount of water available for the plants. The amount of water also affects the kinds of animals living in the community. Different kinds of plant communities attract different kinds of animals. Animals that live in the forests are not the same as those that live on the grasslands.



Water in the Air

The water that falls on the earth as rain, snow, sleet, or hail is called precipitation. The map on this page will help you understand how the amount of precipitation a region receives depends on its location. This in turn affects the communities in the region.

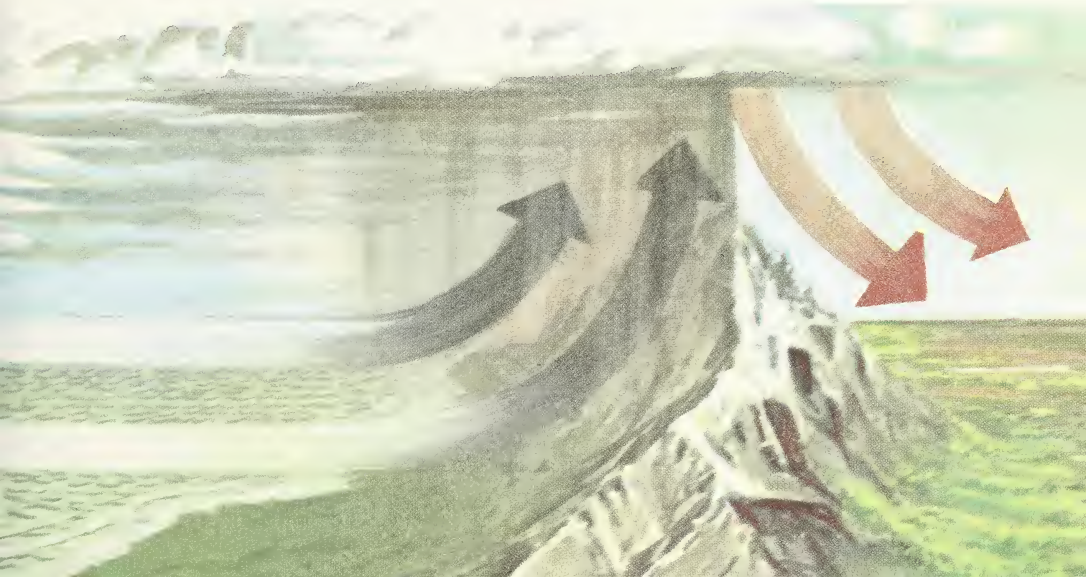
Winds blow off the Pacific Ocean toward the west coast. The winds pick up a great deal of moisture as they move across the ocean toward the land. They sweep across the land and are forced up and over the Sierra Nevada–Cascade Mountain Range. As the air is forced up, it begins to cool. The cooler it becomes, the less moisture it can hold. Most of the moisture in the air is dropped as rain or snow on the ocean side of the mountains.

You might try an experiment which may help you to understand why this happens. You will need two water glasses. Containers made of aluminum work very well, but any kind of drinking glass will do. Make sure the glasses are dry inside and out. Then pour hot water into one and fill the other with ice. As you fill the glasses, be very careful not to allow them to become wet on the outside.

Observe the outside of each glass. In a few minutes you will notice that the outside of one has become very wet, although the other is still dry.

The air in the room surrounds both glasses. One glass is hot and the other is cold. The air is warmed as it comes in contact with the hot glass, but it is cooled by the other.

The water forms on the outside of the glass which has the ice in it. As the air in the room is cooled, it gives up its moisture. This is because cool air can hold less moisture than warm air. It is for this same reason that the air on the ocean side of the mountains drops its water as rain or snow. As the air is forced up the mountains, it becomes cooled and cannot hold as much water as it did when it was warmer.



Very little rain falls in the region to the east of the mountains along the Pacific coast. When the air finally gets over the mountains, it is very dry. As it passes over the land just beyond the mountains, the air contains little moisture. If you look at the map on the opposite page, you will notice that this part of our country is a very dry region.

Communities of plants and animals that live well where there is an abundant supply of water are found on the ocean side of these mountains. On the dry side of the mountains the natural communities of plants and animals must be those that can get along with much less water. The two groups of communities are very different.

Rain and Other Regions

The Great Plains extend from Mexico into Canada. This region is one of high plains, which are from 3000 to more than 4000 feet above sea level. Much of the air that moves across this region comes from the dry land of Mexico. As it moves north over the Great Plains, it is warm and dry. It may rise and be cooled as it travels across the plains, but it contains so little water that not much rain falls. Most years are dry, and rain may not fall on more than 120 days in a year. It is often so dry that irrigation is needed to provide water for crops.

At times moist air does travel over the Great Plains, and when the air is cooled, much rain may fall. The rain that falls on one day may be more than a third of the rainfall of the whole year.

The natural plants of the Great Plains area are short grasses such as buffalo grass. This grass can stand the long periods during which there is no rainfall. Herds of buffalo were able to live on this short, tough grass. If proper care is taken, cattle can profitably graze on this land.

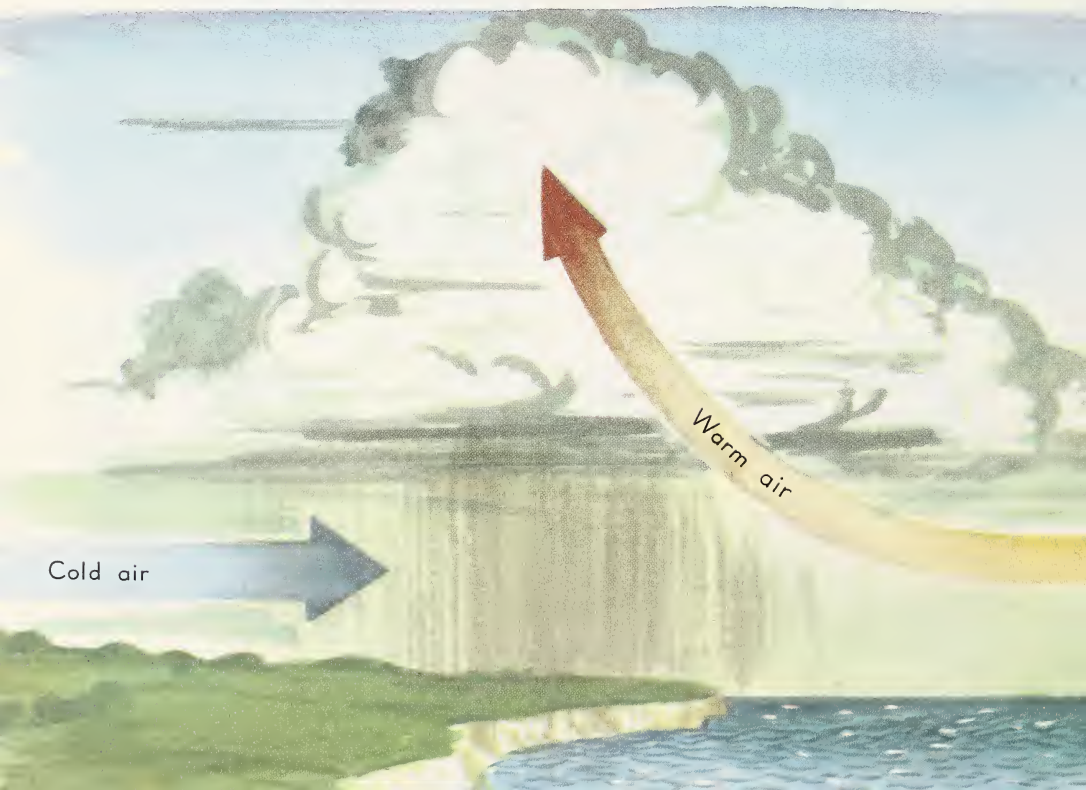
The prairie region lies in the heart of the continent. Warm, moist air from the Gulf of Mexico moves up over this area. When the air becomes cooled, it loses its moisture. Since rainfall is usually heaviest here in June, cereal crops grow well in this region. There is usually plenty of water for the plants when they need it for growth.

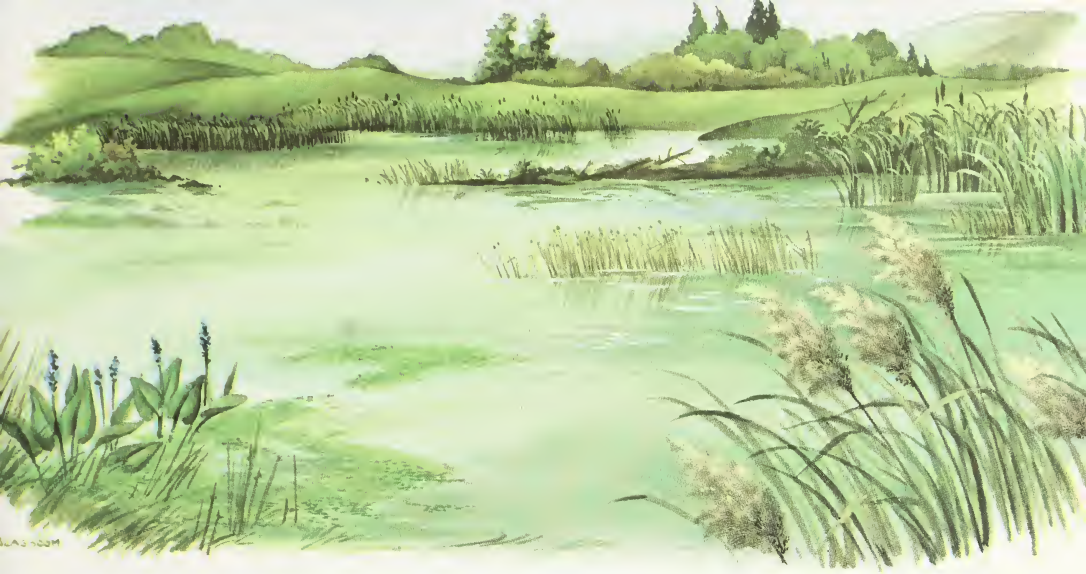
Look at the map. Can you suggest a reason why rain falls on the eastern part of the country? Warm air filled with moisture from the

Atlantic ocean often moves across the land. As it travels northwestward, it may meet dry, cold air which is moving into the eastern region from the north. The warm, moist air will be forced up over the cold air and will be cooled at the same time. As the air becomes cooled, the moisture it carries will fall as rain or snow.

Rainfall is plentiful in the eastern region. This rainfall allows for a great variety of plant and animal life.

The communities of plants and animals found in each region are very different from those found in other regions. Rainfall is one of the most important reasons for this difference. The rainfall in turn depends on the kind of air moving through the region. And we have seen that the movement of air depends on the location of the region. As you stop to think, you can also remember how temperature and energy affect the community. Yes, each of these things plays an important, necessary part in determining what the community of plants and animals will be like.





Studying a Community

You might plan to visit and study some small communities. Throughout the continent one of the most interesting and common communities is the kind that is found in a pond. A pond is a very small body of water and can be found in most regions.

In Shallow Water

The easiest part of a pond to study is the shallow-water area close to the shore. This part of a pond is usually shallow enough for light energy to reach to the bottom. You will probably find many plants with their tops above water and their roots in the soil at the bottom of the pond. In this way the plants are able to obtain carbon dioxide from the air above the pond. Water is taken up through their roots. As light energy falls on the plants, they are able to manufacture food.

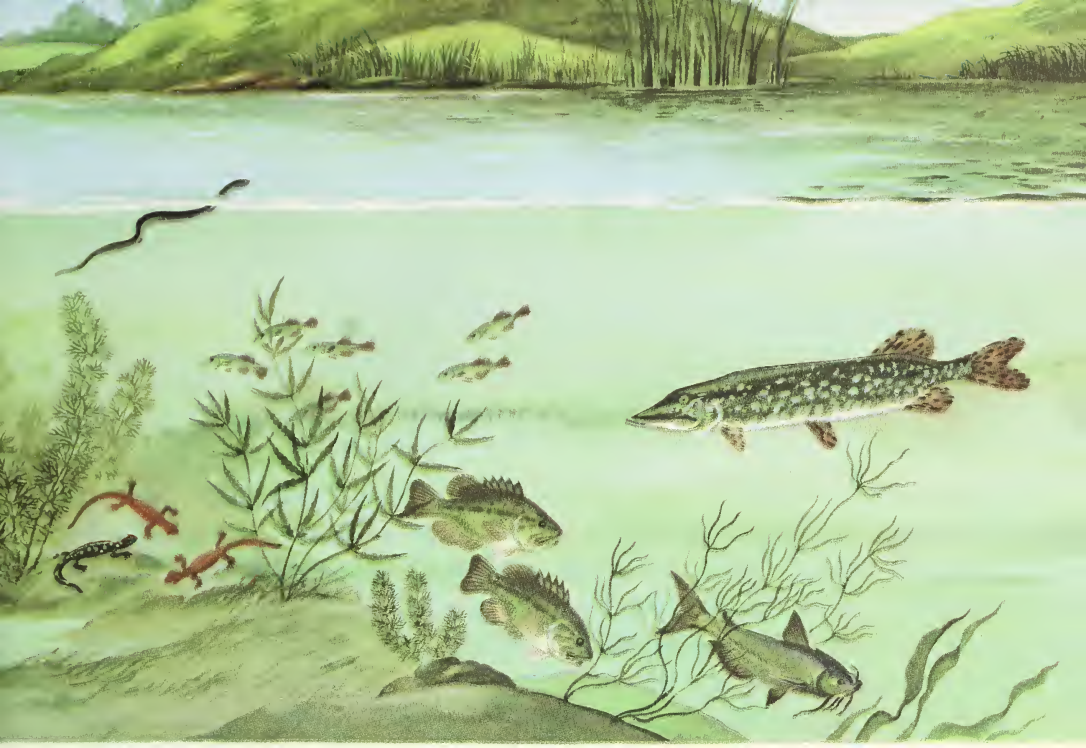
Cattails, bulrushes, arrowheads, reeds, spike rushes, and pickerel weeds might be found in this part of a pond. You may also see some floating green plants such as duckweeds. These plants are not rooted and at times may cover the whole pond.

On many ponds there is a green scum floating on the water. This really consists of green plants called algae. If you examine the scum, you will see that it seems to be made of many tiny, green threads. Algae may often be found growing on rocks and sticks under the water.

In some parts of a pond you may see lily pads. They are to be found in fairly shallow water. The roots of the lilies are in the soil at the bottom of the pond. On the undersurface of a lily pad you may find water snails. Most snails feed directly on the plants and may be found crawling along on some of the underwater stems. You may find other animals attached to the stems and leaves of plants, too.

In Deeper Water

Farther out in a pond you may find many plants which are completely under water. Most of these underwater plants will have thin, finely divided leaves. Pondweed is the name given to some of the most



common of these plants. Other plants, such as coontail, water milfoils, waterweed, naiada, and wild celery, can also be found in some ponds. These plants are able to manufacture plant food because the water where they grow is still shallow enough for light energy to reach them.

Many animals may live in a pond as important members of the community. Some of the most common are frogs, toads, salamanders, turtles, and water snakes. Most water snakes are not harmful, but one should always be careful.

Tiny fish, called top minnows, are usually plentiful among the plants in most ponds. Catfish, bass, and pike may also be present. On the surface of a pond, animals such as whirligig beetles and water striders may be seen.

This is not the end of the story. Many other plants and animals make up a pond community. There is a great variety of life and activity in a pond.

Communities Change

At times the life in a pond may change greatly. Sometimes the changes may be brought about by things outside a pond community. Soil may be washed into the water from the surrounding land and fill a pond. Changes may also be brought about by great growth in the plant life of a pond. This would also start to fill a pond. The community would gradually change from a pond community to one which could live in a swampy area. In some regions of the country changes in a pond may be brought about by a long period of drought. A pond may just dry up.

A pond may gradually change from a water community to a land community. As these changes occur, new balances between plant and animal life in the community come about. This means that the kinds

Prairie chickens

of plants and the kinds of animals gradually change until there is a whole new community. You may know of some pond that has been gradually changed in this way during your lifetime.

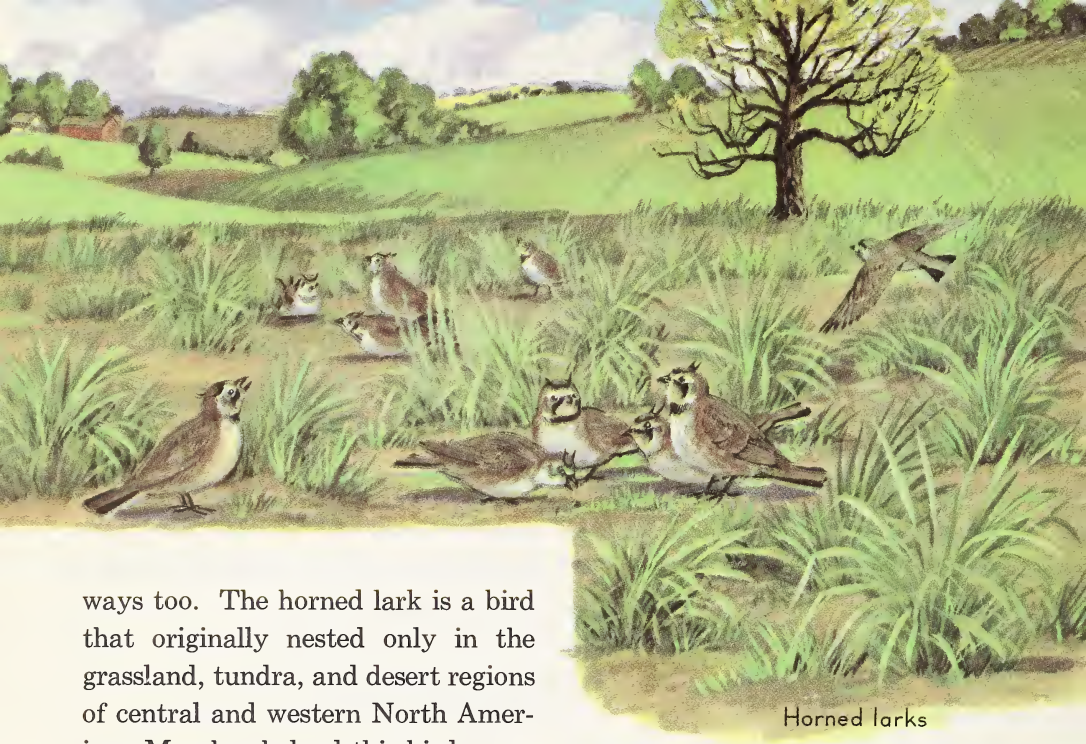
Man Affects Communities

In going about his business of living, man has greatly affected the natural communities of plants and animals which surround him. At times he has disturbed the balance so much that certain plants and animals could no longer continue to live as part of the community.

As man moved into the Middle West, he plowed up the grasslands and planted grain fields. This was a very necessary step forward on the part of man. But as he did this, he disturbed the balance that had existed.

The prairie region was originally covered with grass and wild flowers such as spiderworts, shooting stars, and violets. Some of the grass grew from 3 to 10 feet high. The large communities of prairie chickens which originally lived here were not able to survive when the grassland area was decreased. A grain-field community gradually replaced the grassland community. Over the years man has introduced pheasants as part of the grain-field community.

Man has created a favorable balance for certain animals in other



Horned larks

ways too. The horned lark is a bird that originally nested only in the grassland, tundra, and desert regions of central and western North America. Man has helped this bird.

When men from Europe first settled on the eastern shore of North America, a vast woodland covered the area. Gradually the woodland was cleared. Pastures, cultivated fields, and finally airports were established in place of the forests. Man had really set up grassland communities in the east. This established in the east a plant balance that was favorable to the horned lark. And so the lark spread eastward. It can now be found as far east as New York and Georgia.

Any change man makes in a community will have an effect on its appearance and make-up. When man makes changes in the community balance, he must be sure that they will be to his advantage. If not, he may regret them.

Man has put his understanding of community balance to work for him in many ways. He has come to realize that it is probably the only effective way of controlling the communities of plants and animals

which surround him. There is much to learn. Probably the most important thing man has learned is that he must be very careful. A change of any kind may have far-reaching effects.

LEARNING MORE

1. As the seasons change from summer to autumn to winter, there is a decrease in the amount of energy reaching a community. Describe some of the changes in communities of plants and animals as energy changes take place.

2. Mark out a 12-inch square on a section of soil. You might think of this as a little community. What kinds of plants do you find growing? Do you see any animals?

Dig down into the soil about 10 or 12 inches. If you are careful, you will find many things such as roots of plants, earthworms, and many other animals. Keep a record of the kinds and numbers of plants and animals that you find in this section of soil.

You might do the same for little sections of soil in different places. Compare your records when you have completed your observations. In what ways do the communities of plants and animals differ?

3. You might look in the newspaper and listen to the daily weather forecasts for news of the air movements over North America. How much rainfall is there in the different regions? Keep a record of the air movements and rainfall for a week, a month, or longer. What effect do you think these air movements and rainfall are having on communities of plants and animals?

4. Observe some of the animals in your community. What do they use for food? You will probably find that some of the animals do not eat plants for food, but they still depend on plants. List some of the ways these animals depend on plants.

5. Examine a fallen log which has begun to rot. You will probably find mosses, ferns, and mushrooms growing around and under the log. When you break off a piece of the log, you may even find an ant nest in it. What other plants and animals can you find in and around the log? Do you think the log forms a little community? What reason can you give for your answer?

Using Water, Soil, and Forests Wisely

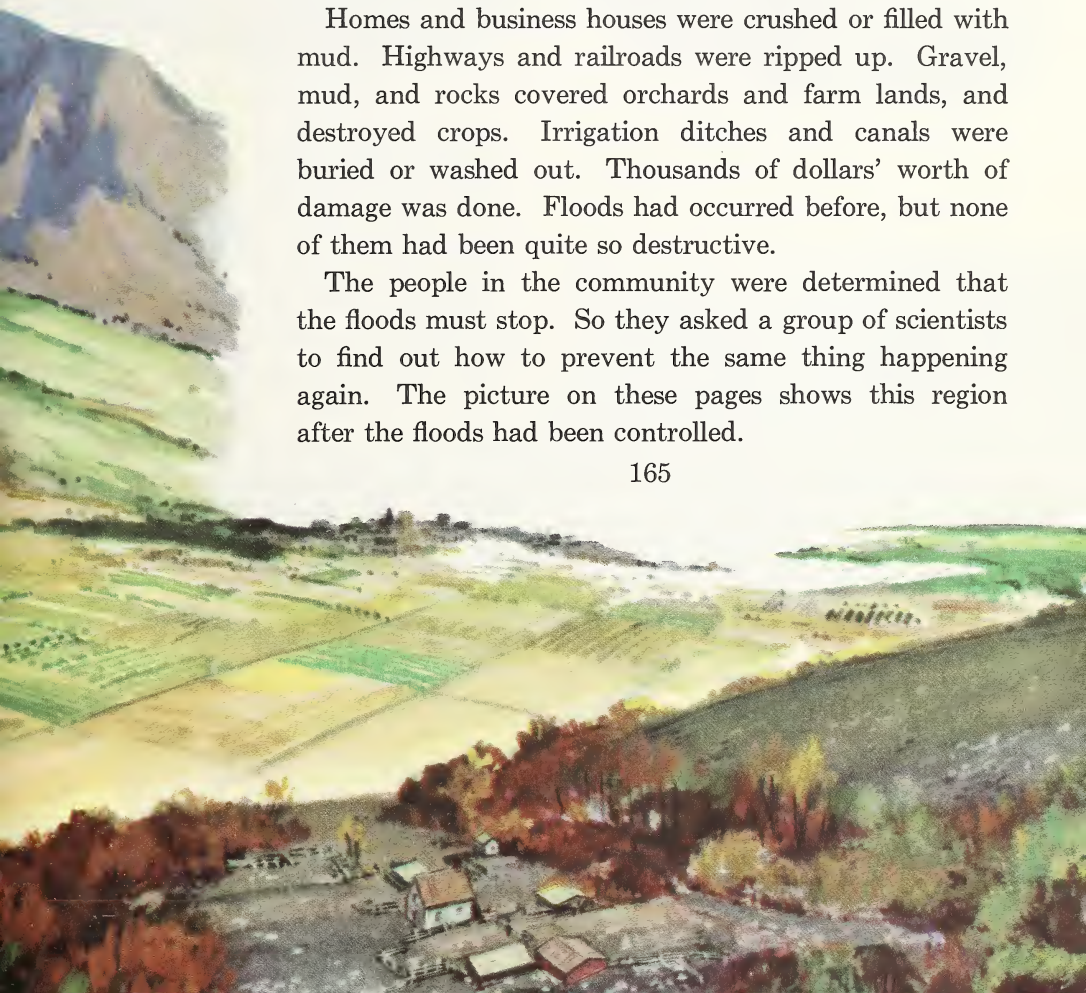
How Can Floods Be Prevented?

"Mud-rock Floods Wreck Town—Destroy Life and Property." Such was a headline some years ago in a newspaper of a city in the western part of the United States. The flooded town nestles at the foot of high mountains.

The storm started in the mountains on a hot, sultry day in mid-summer. Rain fell rapidly for several hours. As water rushed down the mountainsides, rocks and mud, gravel and boulders were carried with it.

Homes and business houses were crushed or filled with mud. Highways and railroads were ripped up. Gravel, mud, and rocks covered orchards and farm lands, and destroyed crops. Irrigation ditches and canals were buried or washed out. Thousands of dollars' worth of damage was done. Floods had occurred before, but none of them had been quite so destructive.

The people in the community were determined that the floods must stop. So they asked a group of scientists to find out how to prevent the same thing happening again. The picture on these pages shows this region after the floods had been controlled.



Rain on a steep, bare slope

Rain on a gentle slope

The Slope of the Land

Scientists studying these disastrous floods found that the flood waters came from the top of mountains behind the town. They said that the steep slope of the land had much to do with causing the floods.

We know that the slope of the land partly determines what happens to rain water. When rain falls on a steep, bare slope, much of the water will run off, and it will carry part of the soil with it.

Scientists know that the plants growing in an area also have a great deal to do with what happens to rain and melting snow.

Plants hold back falling water. They allow it to soak slowly into the soil. When there are no plants, the water runs off quickly.

Think how much water would run off slopes that have little grass or other plants growing on them. There would be nothing to hold it back. The swiftly moving water would rush down the slopes carrying soil with it, and it might cause floods on the land below. When this happens, water is harmful.

When there are plants covering the ground, some of the water sinks into the ground. The rest of it gradually flows into streams and lakes. Then we have a supply of water that is useful.

A Look at the Soil

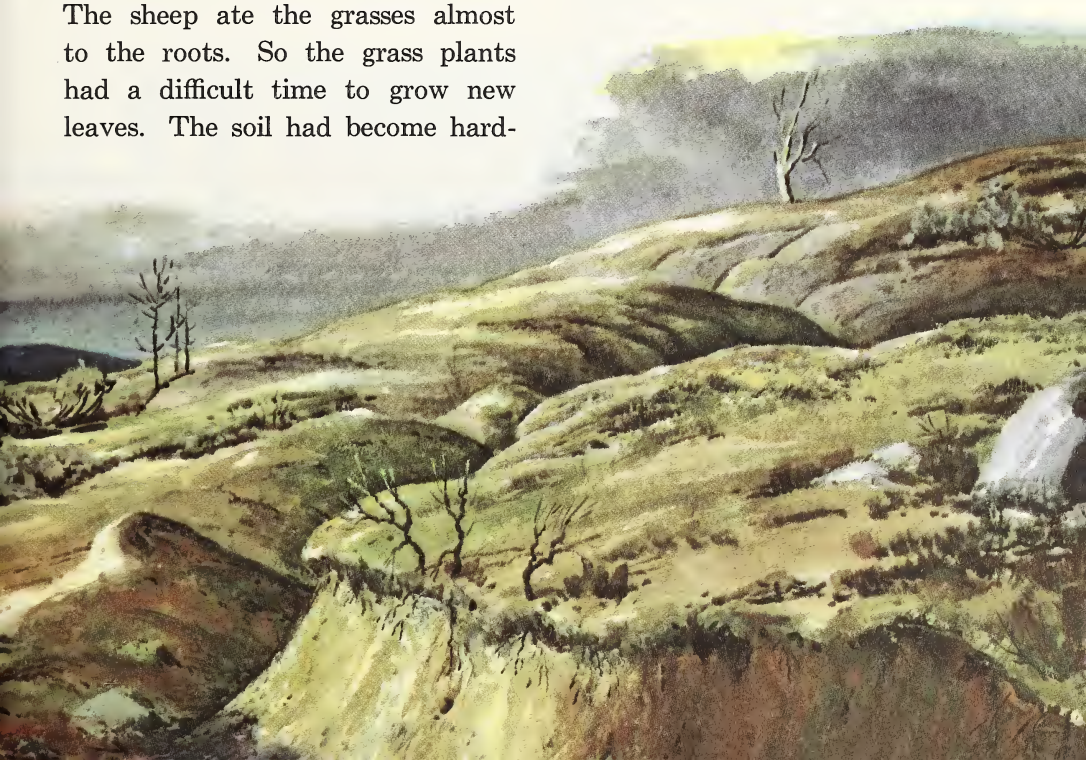
The soil on the mountaintops from which the floods had come had little plant life growing in it. The soil did not contain much moisture. In fact, its surface was hard.

There were patches of dead and dying plants which at one time had been growing in good soil. Some of the shrubs were blackened by fire. There was no grass. These were signs that the land on these mountains had not been used wisely. The soil had been abused.

What caused this to happen? The owners of the land had brought too many sheep to feed in this area. The sheep ate the grasses almost to the roots. So the grass plants had a difficult time to grow new leaves. The soil had become hardened by the trampling feet of so many animals.

Then the land owners had set fires to burn the thick brush that covered parts of the mountaintops. By doing this, they hoped to make room for new grass to grow. Instead, the fires destroyed most of the plants which covered the soil.

As a result of these abuses there was nothing to hold the rain as it fell. Water rushed down from the hard, bare slopes, carrying mud and rocks with it. It did not take a heavy rainfall to cause a flood in the valley below.



Contour trenches

The People Take Action

After the causes of the floods were known, something needed to be done. The people decided that no animals would be allowed to graze on the mountains, and no fires could be built. They made plans to change the slope of the land and to plant grasses on the bare spots.

To accomplish this, huge ditches were dug, curving across the slopes of the mountains. They were dug about 25 feet apart and they covered more than 1000 acres of the mountain slopes.

These ditches, dug by machines, are called contour trenches. Contour trenches catch and hold the water from rain and melting snow. The water cannot run down the mountainsides, causing floods. The trenches hold back the water and allow it to soak into the soil.

Between the trenches a mixture of different kinds of grass seed was planted. The moisture in the soil helped the plants to grow quickly. Soon the plants began to cover the mountain slopes.

Today the people who live in the town below these mountains do not have to worry that their crops and homes may be destroyed by mud-and-rock floods.

Look around Your Community

You have been reading the story of a community that learned what happens when land is overgrazed and plants are destroyed by fire. It is also a story of what can be done to restore land, so that it again produces plant life and prevents floods.

Think about your own community. Do you see steep hillsides covered with so few plants that rain or water from melting snow rushes down the slopes? Is soil being washed away? Perhaps there are areas where fires have destroyed trees and grass and other plants.

If these are some of the things you observe where you live, then the land is being abused. In some places water may have cut into the soil forming deep gullies. When rain falls or snow melts, the water rushes down gullies making them deeper and carrying away the soil.

One way to prevent water from rushing down a gully is to build a check dam. The picture below shows one kind of check dam. You can see the straw and brush held in place by fence wire stretched across the gully. This kind of check dam will catch and hold much of the soil in small gullies.

In addition to building check dams, it is possible to plant different kinds of grasses, shrubs, or trees in such gullies. The kinds of plants depend on which grow best in the area. However, it takes a long time to build up the soil. It is difficult to start any kinds of plants growing again when land has been abused and soil has washed away.

Perhaps bare slopes in your community have been reseeded to various kinds of grasses and other suitable plants. Sometimes bare slopes are planted with a kind of grass that has long, slender roots. These roots grow out in all directions. They hold the soil and prevent it from washing away. This is one way in which water and soil can be wisely used.

Using Water Wisely

It is fortunate for us that there is so much water on our earth, because we use a great amount of it. What are some of the ways in which we use water?

It takes a great deal of water to grow our food. To raise a stalk of corn requires about a barrel of water. It takes more than 1000 gallons of water to grow a bushel of corn. To raise an acre of corn requires thousands and thousands of gallons of water. The plants must get this water from the surrounding soil.

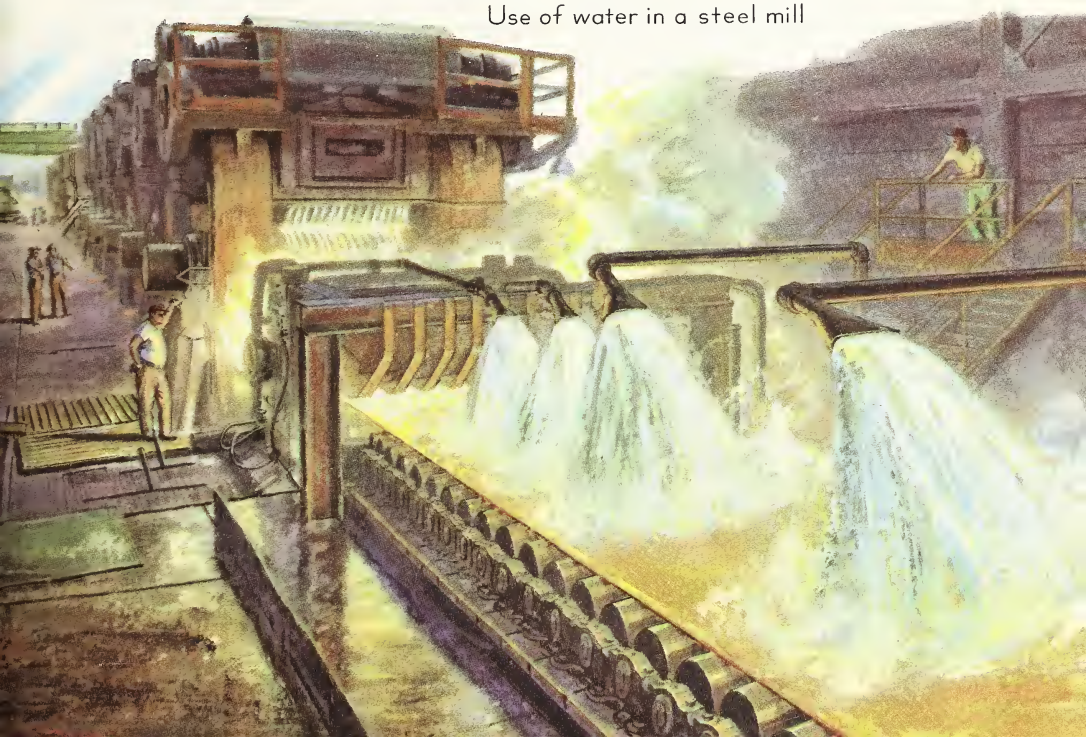
The animals that provide us with food need even more water than plants do. Animals drink a great amount of water each day. A milk cow may drink as much as 25 gallons a day. Animals also eat plants that use water. It takes almost 100 gallons of water to raise every pound of hay a cow eats.

In our factories we use a great deal of water. A paper mill uses millions of gallons of water every day to make the wood pulp from which paper is made. Cotton mills use many gallons of water in the process of finishing cloth.

A steel mill needs gallons and gallons of water each day. Many other kinds of factories also need water in making the things they produce. You might find out what some of the biggest uses of water are in your community.

Since we use such great amounts of water, we can understand why water is so very important to us. We each need many gallons of water a day to keep our bodies clean and healthy. In fact, we know that we could not live without water. Where do we get all the water that we need?

Use of water in a steel mill



Where Water Comes From

We know that large oceans cover our earth. We also know that ocean water is salty, and in order to use it, we must remove the salt. At present it costs too much to remove salt from water by any method we know about. So our best sources of water are rain and snow.

When rain and snow fall on the earth, any one of these three things may happen:

1. Some of the water from rain and melting snow may go back into the air. The water evaporates from the ground and plants.

2. Some water may run off the place where it falls and flow into lakes, rivers, and oceans.

3. Some water may sink into the ground. This is the water that fills our wells. Some of it flows beneath the ground into nearby lakes and reservoirs.

Just what happens to rain water depends on several things. If a light rain falls on a forest or on grassland, most of the water will soak into the soil. But if a heavy rain falls on this same land, some of the water will run off into nearby streams. It cannot soak into the soil fast enough. The heaviness of the rainfall is one thing that determines what happens to water.

You can see what happens when a heavy and light rain fall on a grassy spot. First, get permission to use

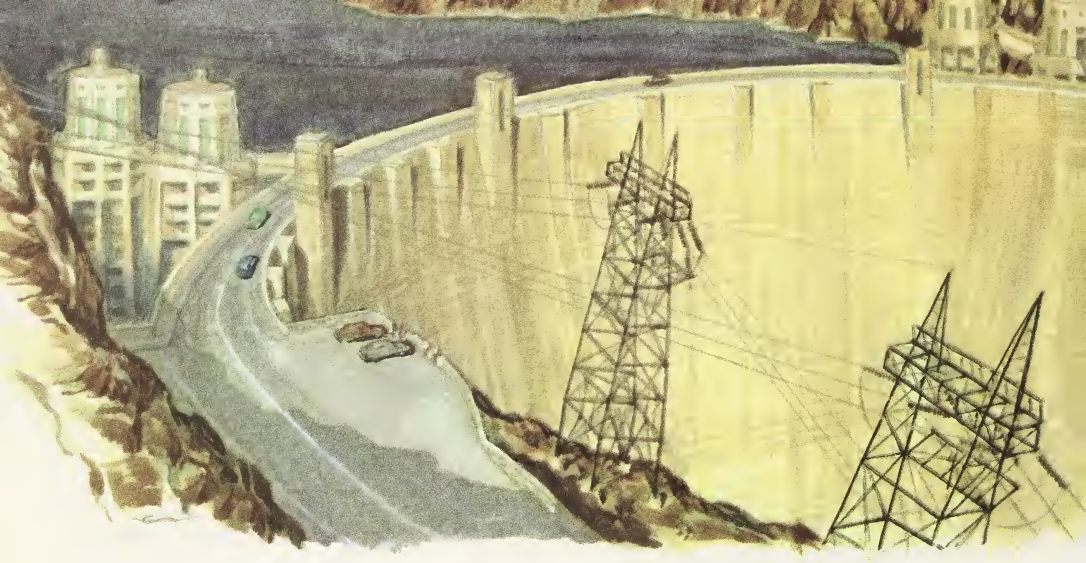
two grassy spots on the school grounds or in your neighborhood. You will also need a watering pot and a pail of water.

With the watering pot sprinkle water on one grassy spot. Notice that drops of water collect on and around the grass blades. The water gradually soaks into the ground. This is what happens when a light rain falls on a forest or on grassland.

Now pour the pail of water on the second grassy spot. Observe that some of the water soaks into the soil, but much of it runs off in all directions. You may even see some of the soil washed away around the blades of grass. From this demonstration you can understand what a heavy rain might do.

Not all parts of the country receive the same amount of moisture each year. You might like to look again at the map on page 152. You can see from this that the average amount of precipitation each year in the United States and Canada varies from 10 inches to over 80 inches.

In some places farmers can count on enough rain falling on their fields each year for them to raise their crops. But in other places farmers must depend on additional water from wells or springs or reservoirs. All this water was also once rain or melted snow. To be of use, it may have to be piped or carried by streams many miles from the place where it originally fell.



Building Dams for Many Uses

One of the largest reservoirs in the United States is Lake Mead, a man-made lake. In the picture you can see the huge dam holding back the water in Lake Mead. This is Hoover Dam in Nevada and Arizona, built on the Colorado River.

The water stored in Lake Mead comes from the rain and snow that falls on lands along the Colorado River and its tributaries. Some of the water stored in Lake Mead is used by farmers to irrigate their crops.

The water that flows from this lake down into the canyon of the Colorado River produces a great deal of energy. If you should visit Hoover Dam, you would see huge machines called generators that use the energy of the falling water to make electricity. This electricity is used by many people who live in Arizona, Nevada, and Southern California.

Below Hoover Dam there is a system of other dams. The map on the next page shows you some of the smaller dams built along the lower part of the Colorado and on some of the streams that flow into it. Some of these smaller dams are used to store water for irrigating crops. They produce electricity too.

These smaller dams also are used to prevent land from being flooded in the spring. At this time of year rain and water from melting snow

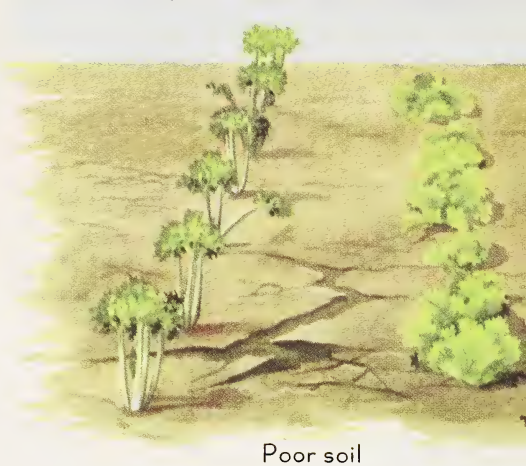
may rush off mountain slopes into streams. The streams become swollen and might flood over the land if there were no way to control the flow of the water. The dams hold back some of the water and prevent floods.

Dams have still other uses. In many parts of the United States and Canada farmers build small dams across streams on their land to make ponds. The water stored in the ponds may be used for cattle and other farm animals to drink. It may also be used for irrigating crops.

Many farmers stock their ponds with fish. The fish provide food for the people living on the farms, as well as sport for those who like to fish. Ponds also provide places for swimming and, in cold parts of the country, for ice skating.

Whether water is useful or harmful to us depends on how well we control its flow. In the past, people have cared little about the source of their water. Yet having a safe and useful supply of water is something that is important to each one of us.

Good soil



Poor soil

Using Soil Wisely

All of us depend on soil. Nearly everything that we eat, use, or wear, as well as the houses we live in, depends on soil. Think of the foods you have eaten today. Probably most of them came from plants. Plants need good soil in which to grow.

The part of the soil in which plants grow is called topsoil. On some land the topsoil may be several inches thick. In other places it may be as deep as 2 feet. Topsoil is a long time in the making. To make just 1 inch of topsoil takes from 300 to 1000 years. Yet 1 inch of it can be carried away by wind or water in a very short time.

Topsoil contains certain mineral elements. Nitrogen, calcium, iron, and phosphorus are some of the minerals found in good topsoil. When topsoil is lost, these minerals are lost also.

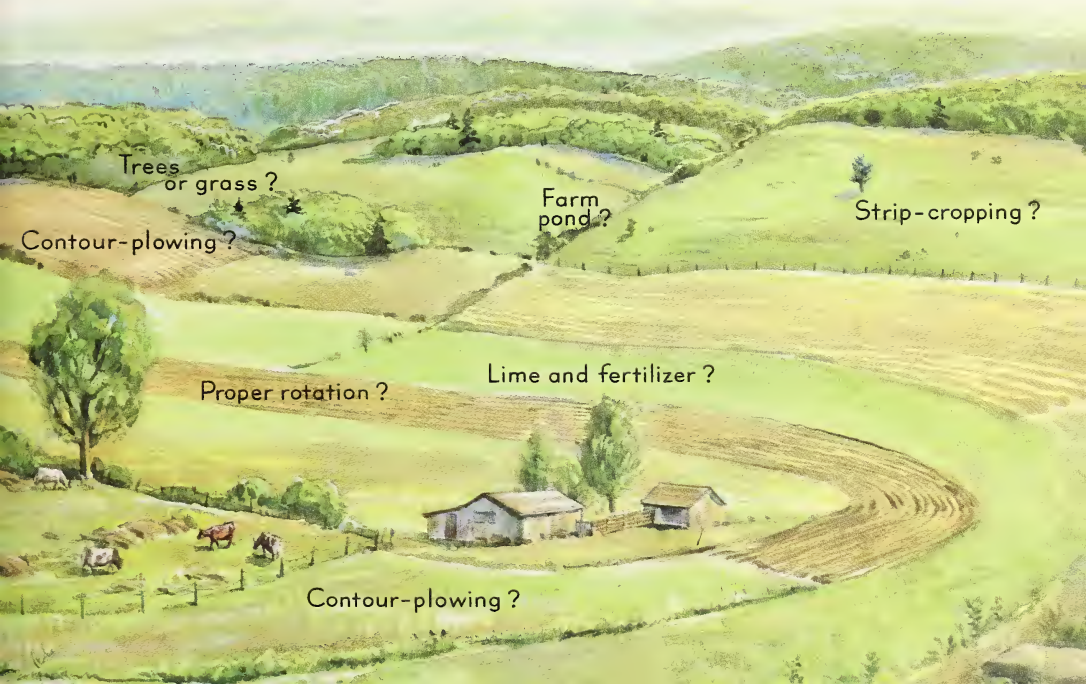
People have experimented with different kinds of plants which we use as foods. They have found that plants grown in poor soil contain smaller amounts of minerals than plants grown in good soil. A stalk of celery grown in poor soil will not contain the same amount of calcium or phosphorus as a stalk of celery grown in good soil. We can see that it is important to everyone that farmers use their land wisely.

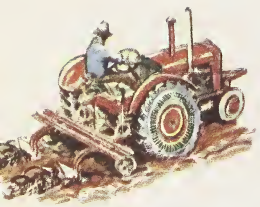
A Farmer Makes a Plan

How does a farmer go about making a plan for his land? First, he may ask the Soil Conservation Service to work with him. The soil scientist and the farmer may make a map of the farm. They may use a photograph of the farm taken from the air. The soil scientist helps the farmer plot on the map the different kinds of land on the farm.

After the map of the farm has been made, the soil conservationist and the farmer start on the next part of the plan. They go from one field to another observing the land and how the farmer is using it. Then they check each field with the map and decide the best use to which it might be put.

The farmer tells the soil conservationist what crops he grows, the kinds of animals he has on his farm, and the machinery he has. He also tells what kind of farming he wants to do. The scientist helps the farmer to plan ways in which to keep his land producing good crops. He helps him decide what needs to be done in each field to prevent the soil from being washed or blown away. The picture below shows you some of the questions that might possibly need to be answered.





Ordinary plow

Lister

Good Farming Practices

What are some of the best practices a farmer uses on his land? One way to prevent soil from eroding is to use each acre of land for what it is best suited. For example, some land may be suitable only for raising hay or for use as pasture land. If it is plowed up and used for growing grain, it will be wasted land.

The way in which the land is plowed also has a great deal to do with wise use of the soil. Some plows throw the soil in one direction and form a long, narrow dam. Farmers have learned to plow sloping fields so that no water runs off. These fields are plowed along the curve, or contour, of the land. As the farmer plows round and round his land, the rows form a series of earthen dams. These slow up the flow of water and hold most of the rain where it falls. The soil will not be washed away.

Sometimes a farmer uses another kind of plow, called a lister. It makes a furrow by throwing soil in

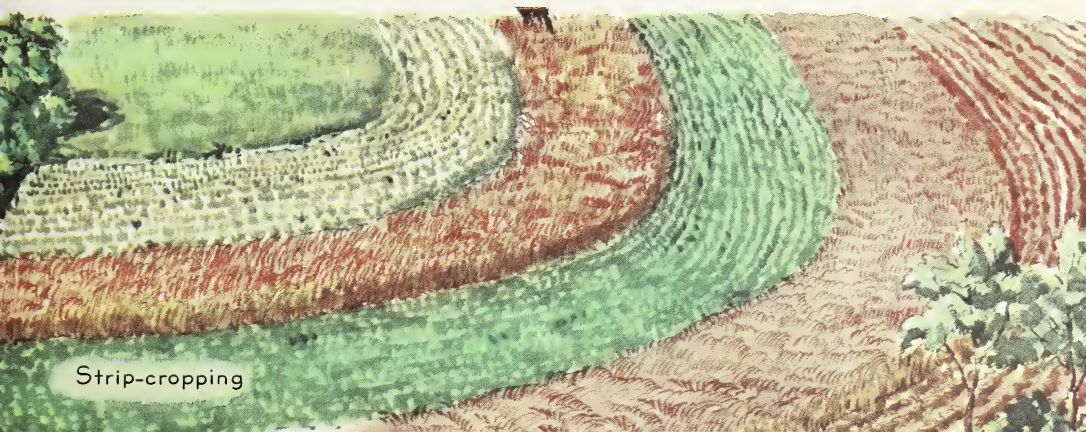
Contour-plowing

Field plowed with a lister

both directions. These furrows keep snow from drifting off the field. When the snow melts, the water does not run off and carry soil with it. When it rains, these furrows hold the rain where it falls; so it will soak into the ground.

Another helpful practice a farmer may use on sloping land is strip-cropping. Strips of close-growing crops, such as wheat, are planted. These alternate with strips of a different type of crop. The strips are planted along the curve of the land.

The farmer in the picture below has strip-cropped his field. He has planted a strip of wheat, then a strip of beans, and then another strip of wheat. His bean and wheat crops will be harvested at different times. Because of this there will be some plants growing continually to hold the soil from washing or blowing away.



Strip-cropping

Farmers have also learned that some crops will enrich the soil by adding nitrogen to it. Alfalfa and clover are two such crops. Others, such as cotton and grain, only remove minerals from the soil.

If a farmer kept on planting the same crops on a piece of land year after year, the soil would soon be worn out. To prevent this from happening, the farmer rotates his crops. If he plans to grow grain for one or two years on a piece of land, he will then plant alfalfa or clover the following year. This is one way in which a farmer puts back into the soil the nitrogen that is necessary for healthy plants.

Using Forests Wisely

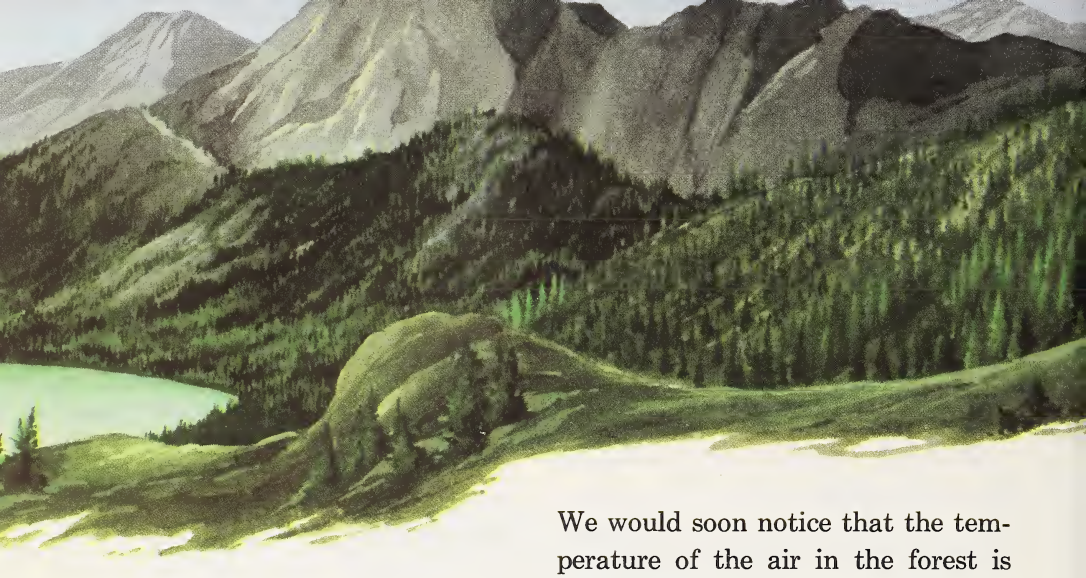
There are many things we use each day that come from forests. We use wood to build homes and to make furniture. We are able to have newspapers, magazines, and books because we have learned to make paper from wood. Many of the containers in which our foods are packaged and marketed are made from forest products. What other ways can you list in which forests are important to us?

How well man manages to live on the earth depends a great deal on how well he maintains the forests. The forests of the earth help to enrich our soil and to control our water supply. They affect the amount of water we have to drink, to grow our crops, and to run our industries.

Forest Watersheds

When rain or snow falls on sloping land, the water drains off into nearby lakes and streams. We call such sloping land a watershed. The hills surrounding a lake or reservoir might be called its watershed. This word is also often used to describe a whole region which drains into a river and its tributaries.

The plants that cover a watershed may be almost entirely trees, or there may be shrubs, grasses, or desert plants. Some areas, like the Mohave Desert in California, have few plants growing on them. Yet many watersheds, such as the Great Smoky Mountains of Tennessee and North Carolina, are covered with dense forests. You can see these forests in the picture below.



If you live in a town or city, the water you use may come from a watershed many miles away. The watershed may be steep mountain slopes like those you see in the picture above. It may be gentle slopes like those in the valley you see in the picture below.

Let's suppose that we could visit a well-protected forest watershed. We would soon notice that the temperature of the air in the forest is quite different from that of the surrounding area. If it is summer, the air in the forest is cooler than the air outside. In winter just the opposite is true. The air in the forest is warmer.

The surface of the ground is covered with a thick mat of dead leaves, twigs, and other plant material. If we should carefully lift several handfuls of this loose material away, we

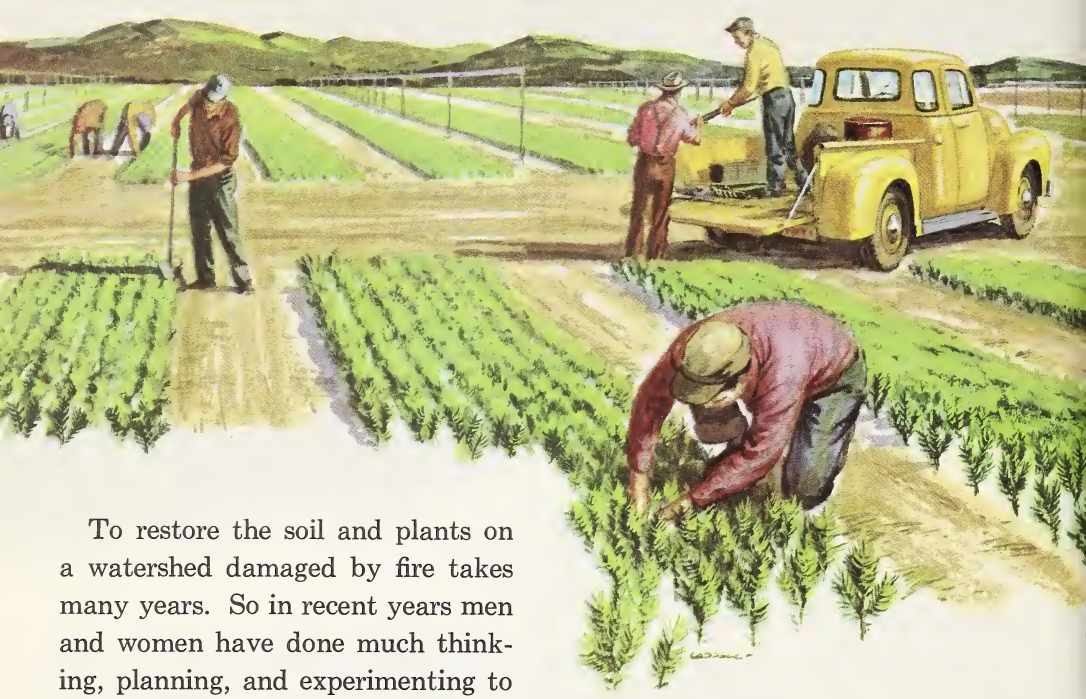
would find a layer of partly-decayed plant life beneath. Below that layer the soil is soft and spongy.

Small animals live in the forest and help to stir up the soil. As they dig and burrow in the ground, they loosen the soil. This helps the water to soak in more rapidly. It also helps to increase the amount of water that the soil can hold. Plant and animal life are very important to a watershed.

If it rains hard or for a long time, a great amount of water falls directly on the ground. Then it moves downward into the soil. Some of this water moves underground and flows into lakes and streams.

Sometimes more rain falls than the soil can hold. Then the rest runs off the ground. On a well-protected watershed little or no soil is carried with the water as it flows into streams. The roots of plants hold the soil in place. So the streams carry clear water to the lands below.

Many watersheds in North America are not giving safe and useful water. These watersheds have been damaged. Fire is one of the worst enemies of a forest watershed. Sometimes just one fire may destroy all plant life in a forest. Animal life in the soil and in the forest may also be killed. Even a part of the soil may be injured. Water running off a damaged watershed may cause floods that destroy farmers' crops and people's property.



To restore the soil and plants on a watershed damaged by fire takes many years. So in recent years men and women have done much thinking, planning, and experimenting to find the best ways to repair damaged watersheds.

Forest Farming

Usually we do not think of trees as being a crop, but they are. However, to raise a crop of trees takes much longer than to grow a crop of something such as corn or wheat. To ripen a field of corn or wheat takes only one year, but trees take many years. It may take as long as 100 years for a tree to grow. Of course we do not have to wait that long. Our forests have trees growing in them that are of all ages.

You have probably walked through a forest and seen small trees a foot or so high growing under tall trees. These small trees are called seedlings. If fire is prevented in the forest, many of these seedlings will grow until they are ready to be harvested.

In some areas where fire has destroyed the trees, people must help the land to a new start by planting seedlings. These seedlings are raised in nurseries from seeds.

The people in the picture above are weeding the beds in a large tree nursery. Here five million young

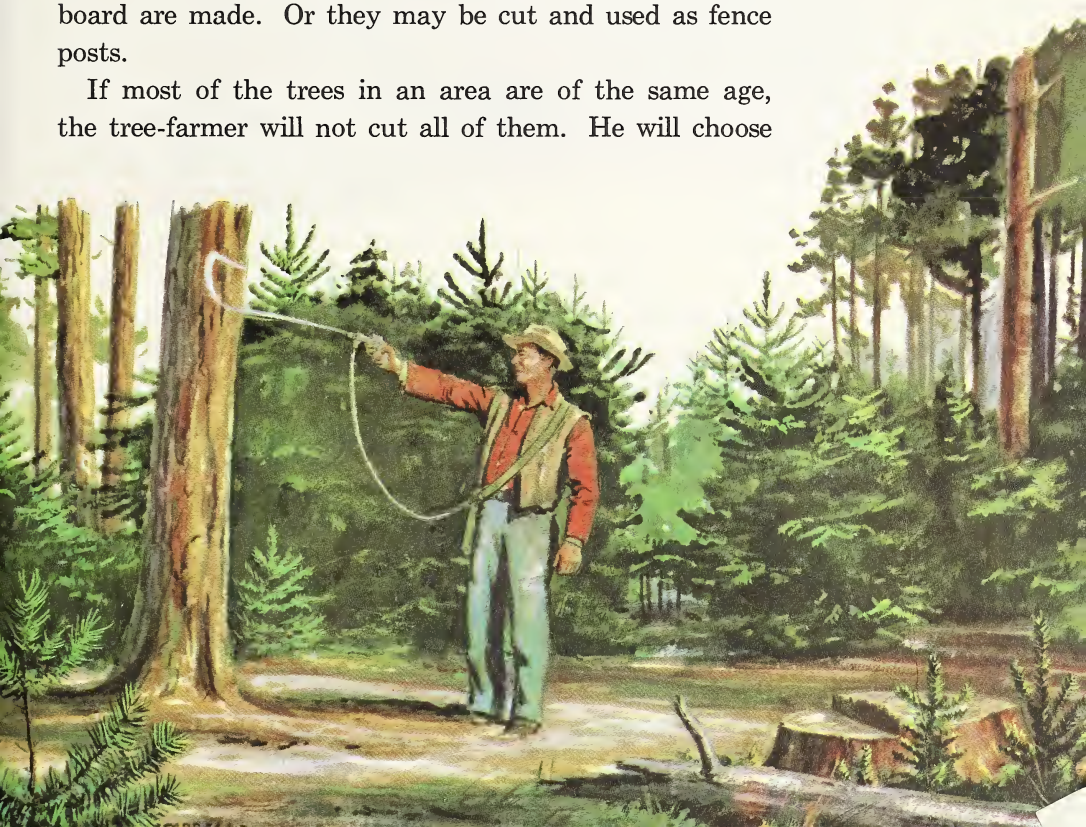
trees are growing from seed. When the seedlings are large enough, they will be planted on land where the forests have been destroyed by fire.

In some forests many trees are already fully grown and are ready to be harvested. If they were left standing, they would die of old age. When these old trees have been cut, the young trees will have more room and sunlight. They will be able to grow faster.

In other forests most of the trees may be young, but here too certain trees are thinned out. The farmer in the picture below is marking with paint the trees he wants to cut. You can see how close together the trees are growing. By thinning out this forest, the tree-farmer will be able to grow a better crop of trees. The trees may be sold for pulpwood, from which paper, rayon, and wallboard are made. Or they may be cut and used as fence posts.

If most of the trees in an area are of the same age, the tree-farmer will not cut all of them. He will choose

Seedling fir tree



Animals enrich the soil

certain trees as seed trees. The seeds which these trees produce will spread over the area, and new trees will start growing.

It is possible to grow trees in many areas of land which are not well suited to other kinds of crops. On almost every farm there is some land that is not well suited for farm crops or pasture. Scientists tell us that much of this land can support tree growth. If all such land were covered with a rich growth of trees, it would become a productive part of the earth. Barren soil would become useful. It would be an aid in controlling our supply of water.

As trees grow in barren soil, the soil itself is improved. It gradually becomes more fertile. You might

say that a forest has its own fertilization program. Leaves fall each year and enrich the soil. Animals come to a forest area and add wastes to the soil.

Many tiny animals, such as ants, spiders, and earthworms, make their home in the soil in which trees are growing. These animals carry bits of decayed plant life into the ground. As rain soaks into the ground, it carries some of this fertile material down with it. In this way a deeper layer of topsoil is gradually developed.

So you see, the planting of trees and the making of forests is one important way in which man can improve land. In this natural way barren and unproductive areas of land can be improved and made useful.

THINGS YOU CAN DO

1. Consult the Forest Service or Soil Conservation Service about plans for your community. Find out where erosion is taking place. Is there anything that you can do to help prevent it?

2. If you live near a forest area that has been burned, find out all you can about the cause of the fire. How could it have been prevented? Compare the soil here with soil in an undamaged forest. Perhaps you will be able to start some new trees growing in the burned area.

3. Visit several farms. Notice how each farmer uses his land. What methods are used to keep soil from washing or blowing away? What are the advantages of each method?

4. Select a committee to write to the Fish and Game Commission to find out how it protects wildlife in your state or province.

5. If you live in a city, there is probably a park nearby, which you could visit. Has the grass been trampled down? Is any erosion taking place?

6. Perhaps you can find a gully in your community. If you can get permission, you might build a dam across it by using sticks and rocks. This should prevent the water from washing away the soil. When the gully has been dammed, visit it again after a rainstorm to see how much soil has been held back by the dam. You might plant grass in this soil.

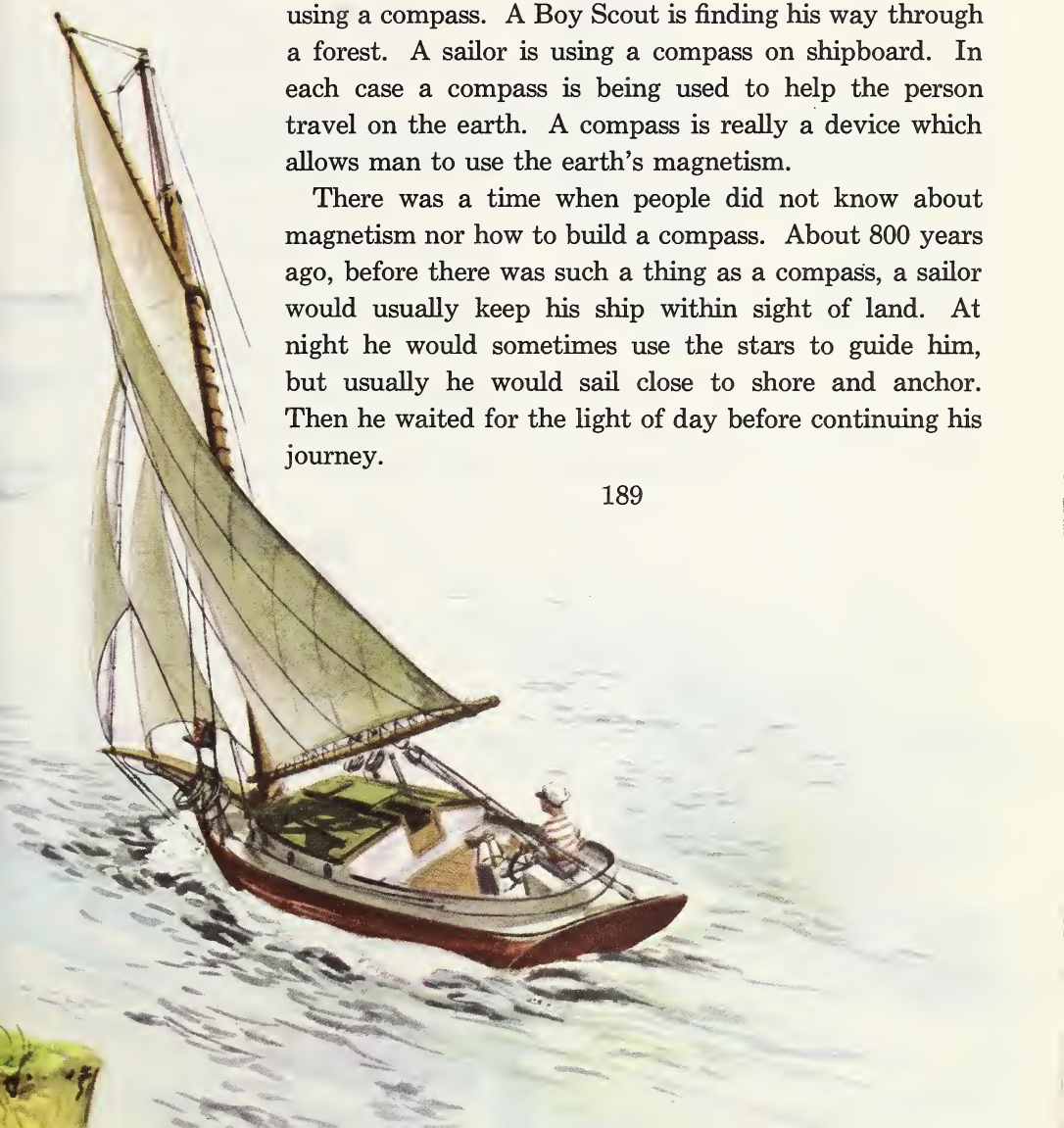
Our Earth—A Huge Magnet?

Using the Earth's Magnetism

Have you ever made use of the earth's magnetism? Perhaps you are not quite sure how to answer this question.

In the picture on these pages you can see people using the magnetism of the earth. Each of these people is using a compass. A Boy Scout is finding his way through a forest. A sailor is using a compass on shipboard. In each case a compass is being used to help the person travel on the earth. A compass is really a device which allows man to use the earth's magnetism.

There was a time when people did not know about magnetism nor how to build a compass. About 800 years ago, before there was such a thing as a compass, a sailor would usually keep his ship within sight of land. At night he would sometimes use the stars to guide him, but usually he would sail close to shore and anchor. Then he waited for the light of day before continuing his journey.



Man made many discoveries about magnetism before he was able to build a compass. But no one is sure when any of these discoveries were made. Long ago someone found that a certain type of rock sometimes attracted iron. The name given to this rock was *magnetite*. When a piece of magnetite acts as a natural magnet, it is often called lodestone.

Later it was found that a piece of this natural magnet would always point in the same directions if it was free to swing. One end of the magnet would point in the direction we call north, and the other in the direction called south.

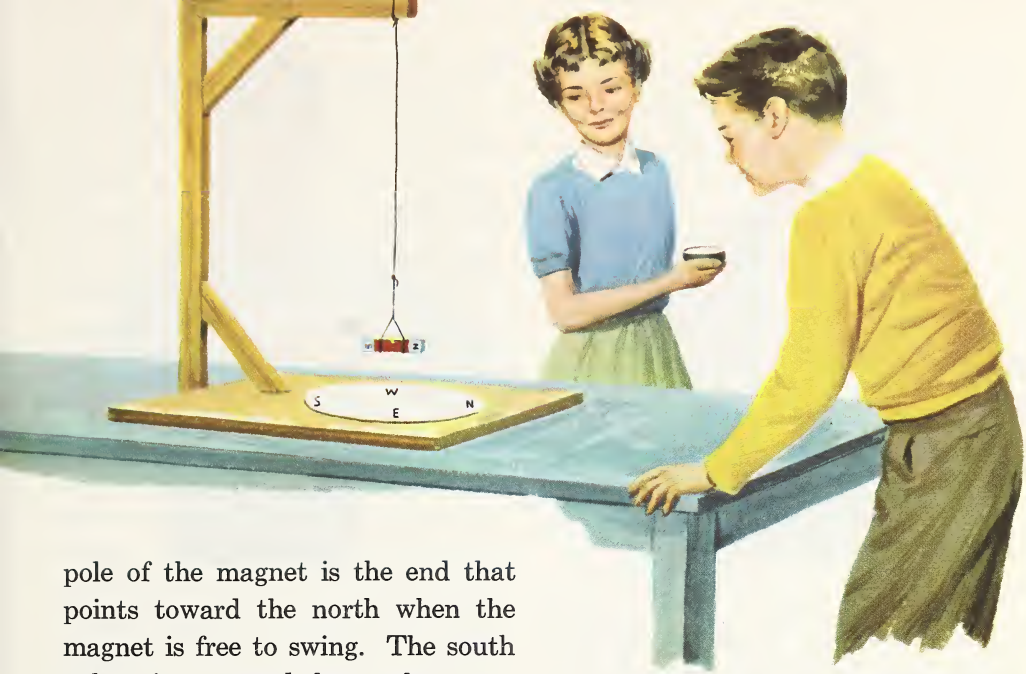
This was useful information. It meant that when a man was lost, he could find his way again by using a magnet. The magnet, when free to swing, would point north and south.

We call such a freely swinging magnet a compass. Compasses were made and used for many years before man had any understanding of how they worked. There have been many different theories about the magnetism of the earth.

Making a Compass

It is not difficult to make a compass. All you will need is a bar magnet and a wooden stand to hang it on.

First, look at the magnet. Often one end of a bar magnet is marked with an *N* and the other end with an *S*. These letters indicate its north and south poles. The north



pole of the magnet is the end that points toward the north when the magnet is free to swing. The south pole points toward the south.

To make a compass, first tie a bar magnet as you see in the picture above so that it will be free to swing. Now cut out a large, circular piece of paper. It should be about 1 foot in diameter. Write *North*, *East*, *South*, and *West* at four points along the edge of the paper, equal distances apart. Place the paper directly under the bar magnet so that the north pole of the bar magnet points to the north position on the paper. Now you have made a compass.

When you have made your compass properly, the words on your piece of paper will correctly show the directions north, south, east, and west. If you have a pocket compass, you can check these directions. Be sure that you do not hold this compass too near the bar-magnet compass you have made. If you should do this, the small compass needle would not point correctly. You will see why later.

Hold the pocket compass steady until its needle becomes stationary. Then carefully turn this compass around until its needle points to the direction marked north on the face

of the compass. Now compare this with the bar-magnet compass you have made. Are the directions the same on the two compasses?

The needle of a compass is really a small bar magnet, mounted so that it can swing freely around. The end of the needle which points toward the north is called the north pole of the compass needle.

Iron Affects a Compass

Men and women who studied the compass were confronted with a puzzling question. What is there about the earth that causes a compass needle to point continually in the same direction? To answer this, they knew that they would first have to find out what affects a compass needle. In one of their experiments they tried bringing a piece of iron near a compass needle, and a very startling thing happened. You can try this for yourself.

Hold an iron nail close to the north pole of a compass needle. Slowly move the nail around the rim of the compass case. You will see that the north pole of the compass needle follows the nail as you move it. Instead of pointing toward the north, the compass needle points toward the iron nail!

Now hold the nail close to the south pole of your compass needle.

The same thing will happen to the south pole as you move the nail.

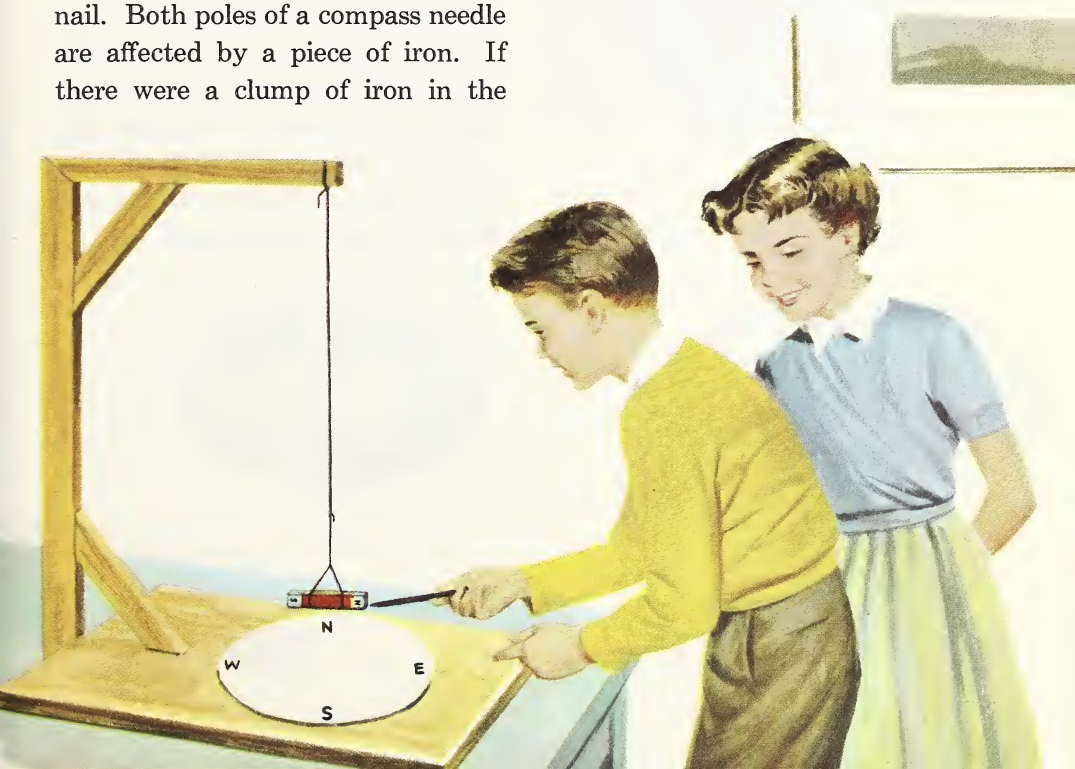
It can be clearly seen that iron affects a compass needle. It was suggested that perhaps the north poles of compass needles point north because they are pointing toward a clump of iron in the northern part of the earth.

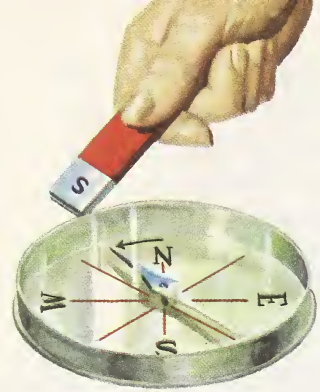
Do you think that this is a good explanation? Think for a minute about your experiment with the iron nail. It is true that the north pole of the compass needle moved toward the nail, but what about the south pole of the needle? That also could be made to point toward the nail. Both poles of a compass needle are affected by a piece of iron. If there were a clump of iron in the northern part of the earth, it would explain why the north pole of a compass needle points toward the north. But why is this not also true of the south pole of a compass needle?

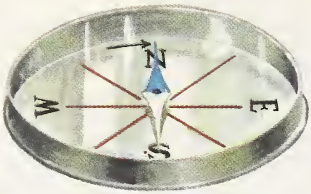
Magnetism Affects a Compass

Scientists wanted a better explanation of the reason why compass needles always point in the same directions. You might try an experiment. You will see that it gives an important clue.

Bring the south pole of a bar magnet near the north pole of a compass needle. Does the compass needle still point to the north? No. It is





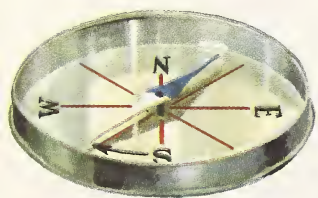


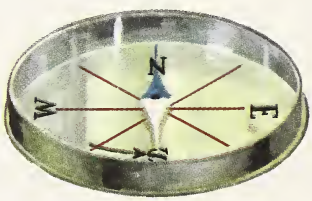
attracted toward the magnet. Take the magnet away, and the north pole of the compass needle swings back toward the north again.

Try bringing this same pole of the magnet near the south pole of the compass needle. The south pole of the compass needle will swing away from the south pole of a bar magnet instead of toward it. When a pole of a compass swings away, we say that it has been repelled.

You will find that the north pole of a compass needle is attracted by the south pole of a magnet, but it is repelled by a magnet's north pole. Do you see what an important clue this is?

Experiments such as this led scientists to say that the earth itself seems to be a huge magnet. They said that the earth must have magnetic poles just as a magnet does. This would explain why compass needles always point in the same directions. It would be because the poles of compass needles are attracted by the magnetic poles of the earth.

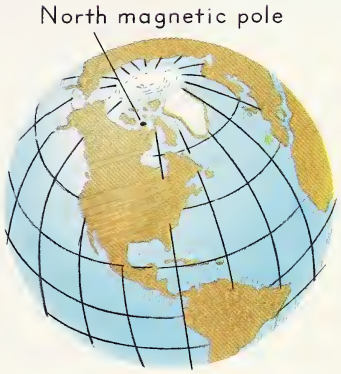




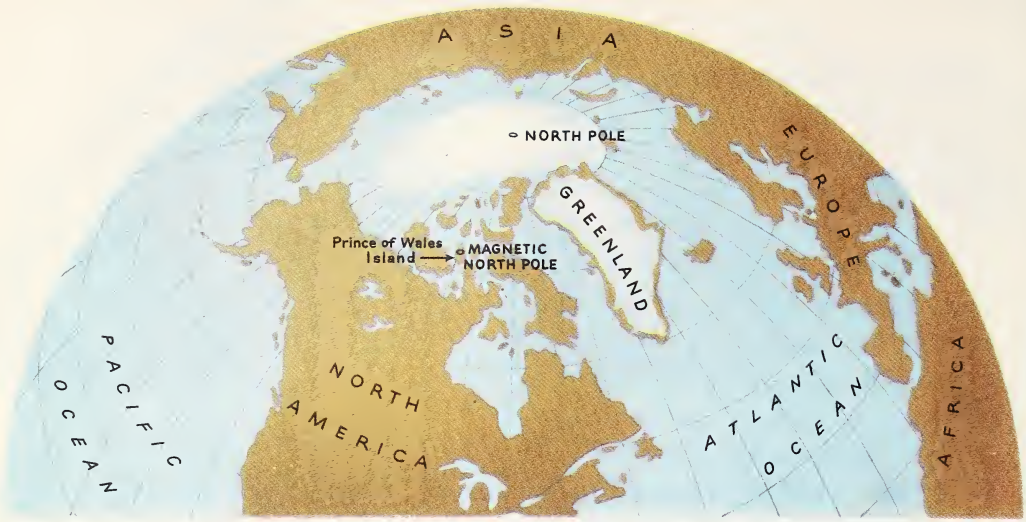
Magnetic Poles of the Earth

It is difficult to imagine that the earth is a huge magnet, but you might imagine that the earth has a bar magnet going through it, as you see in the picture at the right. One pole of the magnet is in the northern part of the earth. The other is in the southern part.

Of course there is no such huge magnet in the earth. But scientists have found that the magnetic force on the earth's surface seems to be concentrated in two definite locations, or poles.



You remember from your experiments that the north pole of a compass needle is attracted toward the south pole of a bar magnet. This means that the magnetic pole of the earth toward which the north pole of a compass needle points must be similar in magnetic force to the south pole of a bar magnet. Using certain special instruments, scientists have found such a pole in the northern part of our earth. The name which has been given to it is the north magnetic pole. It has been located on Prince of Wales Island in the Arctic Ocean. This island is off the coast of northern Canada, north of Hudson Bay.



As you can see from the map above, the magnetic north pole is not the same as the geographical north pole. You know that the earth is turning on its axis. One end of the axis is called the geographical north pole. The compass needle points toward a different spot, however. A geographical pole and a magnetic pole are quite different things.

Look at the map below. Do you see the magnetic pole and the geographical pole in the southern part of our earth? You will find that the magnetic south pole is located on Antarctica. The geographical south pole is on Antarctica, too. But you can see that the magnetic south pole is quite a distance from the geographical south pole.

What Is Magnetism?

Men who study the earth have spent much time trying to explain why the earth has magnetic poles. In order to have an explanation of this, they first had to have an explanation, or theory, of magnetism. Then they were better able to develop theories of how magnetism is produced on the earth.

The Molecule Theory of Magnetism

Some scientists gave an explanation of magnetism which was very useful. This theory was built around molecules. You can call it the molecule theory of magnetism.

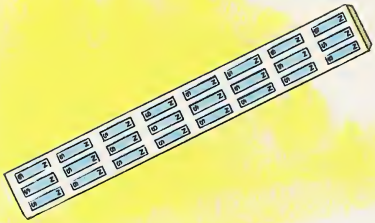
According to this theory all things are made of millions of molecules. You may remember that scientists also say that all things are made of millions of atoms. Perhaps you are not sure just what the difference is between atoms and molecules. We might say that a very small drop of water is made of millions and millions of atoms. It would also be true to say that this same drop of water is made of millions and millions of molecules.

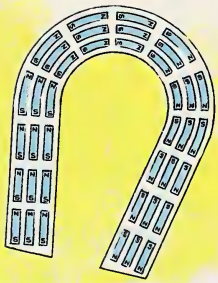
The atoms in a drop of water are not atoms of water. They are atoms of the chemicals of which the water is made. They are atoms of hydrogen and atoms of oxygen. When two atoms of hydrogen combine with one atom of oxygen, they form one molecule of water. This is expressed by the symbol H_2O.

A molecule is the smallest part into which a substance such as water can be divided and still be water. A water molecule is made up of more than one kind of atom. There are about one hundred other substances which are not made up of more than one kind of atom. These substances are called elements.

Hydrogen and oxygen are both elements. Iron is another substance which is made up of only one kind of atom. A small piece of iron consists of millions and millions of molecules, but all the molecules are made up of the same kind of atom. They are all atoms of iron.

The scientists who developed the molecule theory of magnetism said that each iron molecule was a very tiny bar magnet. In this theory each of the tiny molecule magnets would have a north and south pole, just like a large bar magnet.

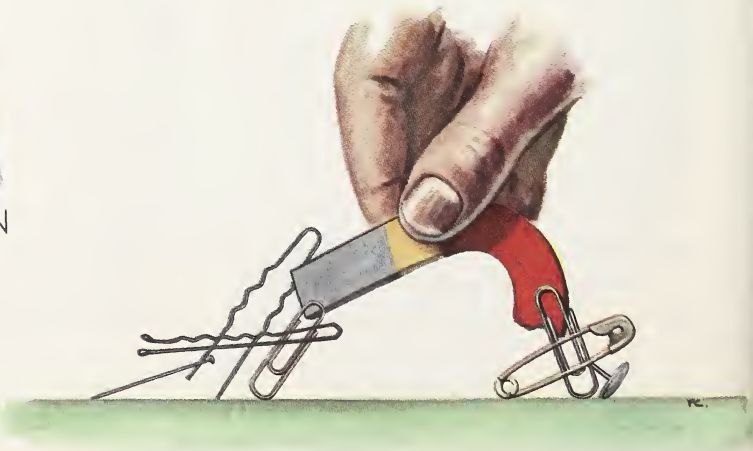




These men said that the molecule magnets in a bar magnet or horseshoe magnet would be arranged as you see in the pictures above. Of course the molecule magnets in a real magnet would be too small to see.

The Molecule Theory Helps

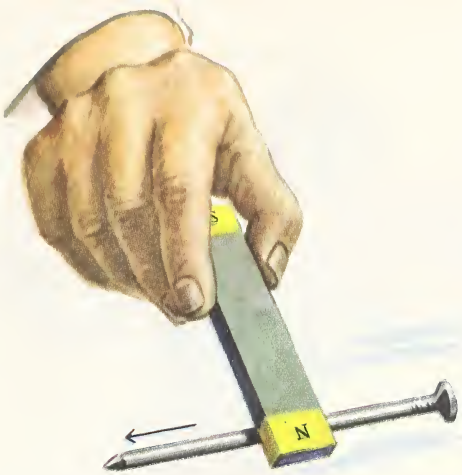
The molecule theory of magnetism helped to explain many experiments. When a magnet is broken in two, the magnet is not destroyed. There are actually two new magnets when this is done. According to this theory, when a break takes place in a magnet, the south poles of its molecule magnets are at one side of the break and the north poles at the other side. You might



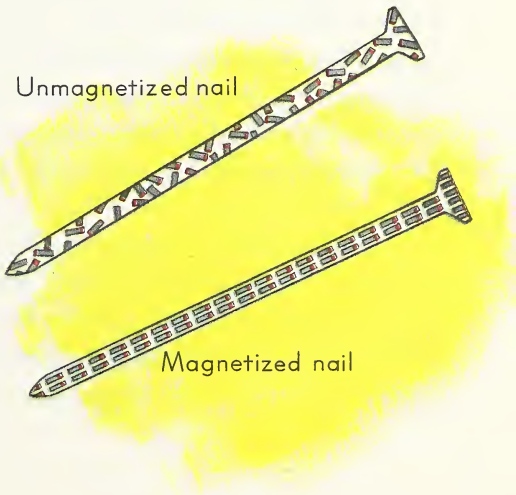
like to try this experiment with an inexpensive magnet, which you can buy in a toy store.

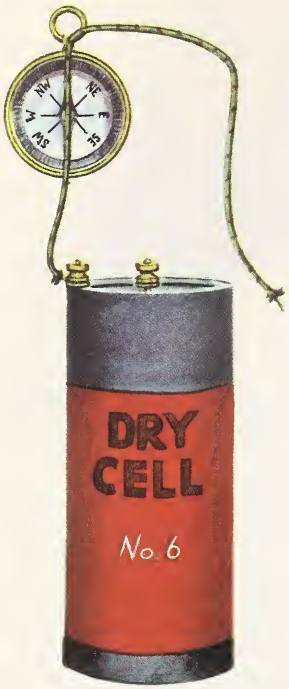
Here is another experiment which the molecule theory of magnetism helped to explain: You will need an iron nail and a bar magnet. Start at the head of the nail and rub one end of the magnet along the length of the nail, as you see in the picture at the right. When you have completed the stroke, lift the magnet from the nail. Then start again at the head of the nail, stroking the nail with the same end of the magnet. By doing this, you will stroke the nail in one direction only. After you have stroked the nail in this way about thirty times, you will find that the nail has become a magnet. You should be able to pick up a paper clip with your magnetized nail.

Remember that the molecule theory stated that each tiny molecule of iron is a small bar magnet. This would mean that any piece of iron is made of small, bar-magnet molecules. In the pictures at the right you will see the way that the molecule magnets of a nail might be arranged. Do you see how the arrangement of molecules has changed after the nail has been magnetized?



According to this theory, after you stroked the nail, the molecule magnets would be arranged so that the north poles all pointed in the same direction. Now the nail would have north poles at one end and south poles at its other end. The nail would be a magnet because of this arrangement of its molecule magnets.





A Change in Theory

The molecule theory seemed to explain many of the known facts about magnetism. But as men and women discovered new facts about magnetism, they began to develop a new theory about it. You might do an experiment which will help you to see what some of these discoveries were.

You will need a compass, a piece of copper wire, and a dry cell. Arrange the wire as you see in the picture on the left above. You will notice that the wire is attached to the outside post of the dry cell and is held over the compass in a north-south direction. Because the needle of the compass is pointing toward the north, the wire is directly above the compass needle.

Now hold the free end of the wire against the center post of the dry cell. Notice the compass needle. It has changed direction! The compass needle now points across the wire.

Disconnect one end of the wire from the dry cell. Electricity no longer flows through the wire above

the compass, and so the compass needle swings back to the north again.

Why does a compass needle move when an electric current flows above it? Scientists knew that one thing which will make a compass needle move is a bar magnet. You can try an experiment with a bar magnet which will show you why this information was very important to scientists.

You will find that there are two ways in which a bar magnet may be brought near a compass to produce the same result as the electric current. Bring the north pole of a bar magnet toward a compass from the west. As you know, the north pole of a compass needle is repelled by the north pole of a bar magnet. The compass needle swings around to the east. It is now pointing in the same direction as when the electric current was flowing through the wire above the compass.

You can also bring the south pole of a bar magnet toward the compass from the east. Does the compass needle move in the same way?

Look at the pictures on these pages. You will see that the results are the same in these experiments. It does not make any difference whether an electric current is used or whether the wire is disconnected and a bar magnet is used. The compass needle moves the same way in either case. But this is the important point: a current of electrical energy can produce the same effect as a magnet.

The Moving Electron

The discovery that a current of electrical energy can produce a magnetic effect was very important. It pointed toward a new way of studying magnetism. As you know, it is believed that a current of electricity is produced by moving electrons. Scientists interested in magnetism began studying the electron.

As you remember, it is believed that the parts of atoms called electrons are electrically charged particles which keep moving rapidly around the center of each atom. While an electron is revolving around the center of its atom, it is moving in another way also. It is spinning, much as a top spins.

It might make you think of the way that the earth moves around the sun. The earth rotates, or spins on its axis, and at the same time it is revolving, or circling, around the sun. In somewhat this same way each electron rotates, or spins on its axis, while it revolves around the center of the atom.

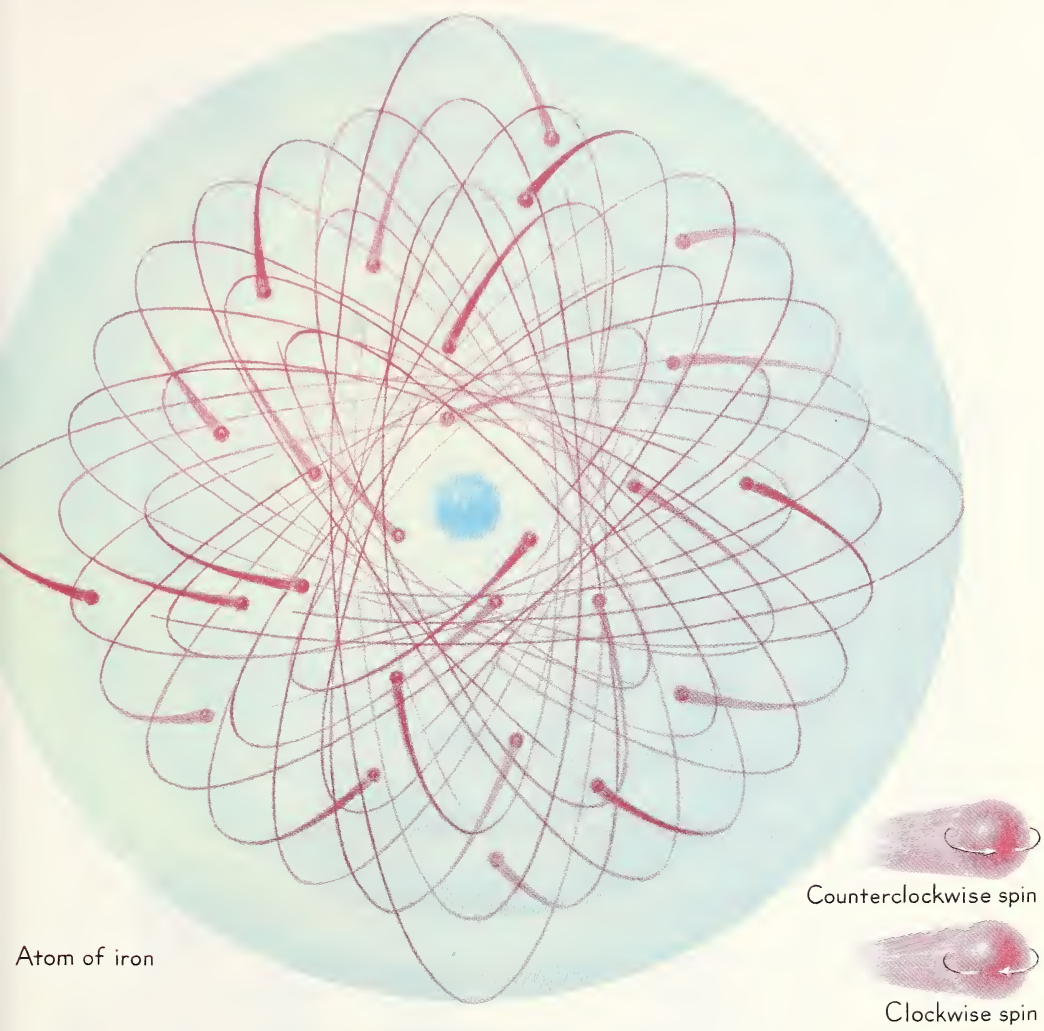
An atom may have many electrons. All these electrons are moving around its center. They are all rotating also, but they are not all rotating in the same direction. Some of them are spinning, or rotating, in a clockwise direction. Some are spinning in a counterclockwise direction.

A piece of iron, such as a bar magnet, is made of many millions of atoms. Each iron atom has twenty-six spinning electrons. This means that there are an extremely large number of electrons in even a small piece of iron.

Some scientists think that these moving, spinning electrons have something to do with magnetism. They believe that in an ordinary piece of iron most of the electrons are spinning in different directions. But they think that in an iron magnet most of the electrons are spinning in the same direction.

Even within the atom the motion of many electrons spinning in the same direction may produce an electric current. In fact, this theory could be called the electron theory of magnetism. According to this theory magnetism is caused by this motion, or current, of many electrons spinning in the same direction.

Can you see how the molecule theory and the electron theory differ? According to the molecule theory any piece of iron is made up of tiny molecule magnets. But a piece of



iron does not become a magnet until these molecule magnets become arranged in the proper order. In the electron theory the molecules of an ordinary piece of iron are not little magnets. Spinning electrons within the iron atoms can cause the iron to become a magnet when most of the electrons spin, or rotate, in the same direction.

The Earth's Magnetism

Scientists who have studied the earth do not always agree on an explanation of the earth's magnetism. However, most scientists say that the earth is magnetic because it is rotating on its axis.

Some people believe that the rapid rotation of the earth has caused the molecules of iron within the earth to be lined up in one direction. In this theory the lining-up of these molecules produces the earth's magnetism. You probably recognize that this theory is based on the molecule theory of magnetism.

Rotation is an important part of still another theory. Have you ever watched water rotating in a basin after the plug has been pulled out? You might fill a sink with water and watch what happens as the water runs out. Do you notice that the water toward the middle is moving faster than the water near the rim of the basin? Something like this may be happening in our earth. The center of the earth may be rotating faster than the outer part of the earth. Not much faster, but some scientists think that there is enough difference in the speed of rotation to produce electric currents in the core of the earth.

Rotation of the earth is an important part of both these theories. You may want to discuss theories

of the earth's magnetism with your friends. In your discussion you should remember that no one really knows what causes the earth to be a magnet.

Attraction at a Distance

We have said that scientists believe that compass needles point north and south because they are attracted by the magnetic poles of the earth. The magnetic poles in the northern and southern parts of the earth are probably thousands of miles distant from where you live. How can they attract your compass needle? Let's do some experiments with a bar magnet which may help to answer this question.

How far away can you hold a magnet and still have a nail attracted to it? In the picture a nail has been placed on a sheet of paper. You can see that a pencil mark has been made beside the nail to indicate its position. A magnet has also been placed on the paper at a fairly large distance from the nail.

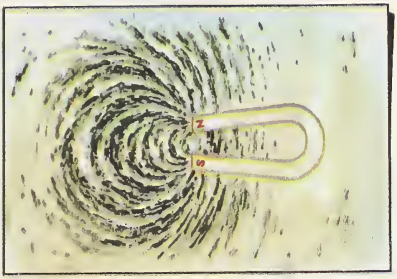
A pole of the magnet should be moved slowly toward the nail. When you first see the nail attracted to the magnet, hold the magnet in place and mark the spot. Now measure the distance between the two marks. This will give you some idea of the distance at which the magnet has an effect on the nail. You can see that a magnet does not have to touch a nail to have an

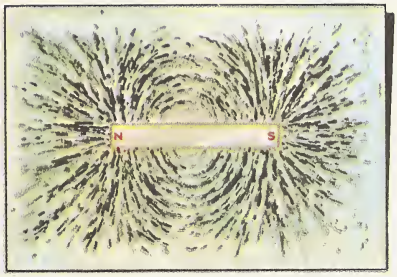
effect on it. We usually say that when an object is attracted by a magnet, it is within the field of the magnet. Let's see what this means.

First, place a small pin on a piece of paper and mark its position. Then slowly move a bar magnet toward the pin. Mark the position of the magnet when the pin is first attracted to it. Leave the magnet in this position, but remove the pin. Now instead of the pin place a rather large iron nail at the mark on the paper where you had first placed the pin. Does the nail move? The field of the magnet must go out this far, because it attracted the pin at this distance. But at this distance the magnetic field does not move the nail.

The field of a magnet may extend for quite a distance, but it becomes weaker as it extends out into space. At a distance the field of a magnet may become too weak to affect a particular object. In your experiment you were able to observe this. You know that the pin was within the field of the magnet, because you saw the pin move. When you placed a nail at this same spot, however, the magnetic field was not strong enough to move the larger, heavier object.

Here is something you can do to get a picture of the magnetic field around a magnet: You will need to have some iron filings for this experiment. Place a magnet on a table and cover it with a piece of





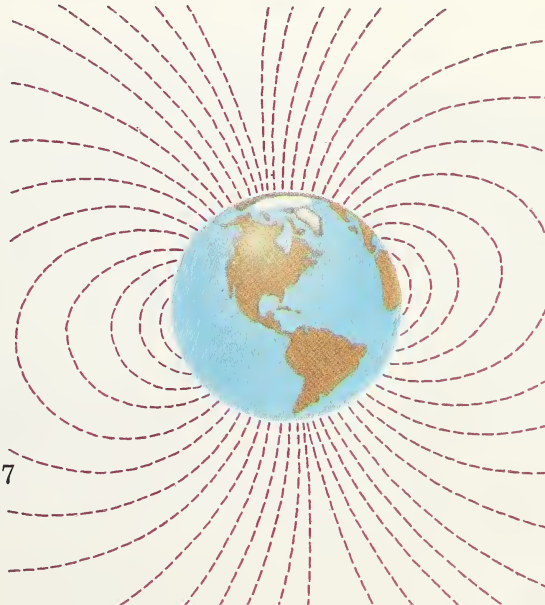
cardboard about 12 inches square. Sprinkle iron filings over the cardboard and gently tap it. Do you see the pattern which they make? Are there filings at the edges of your cardboard which are not affected by the magnetic field? This is because the field is not strong enough there to affect them.

The pictures above show the way that iron filings arrange themselves in the fields of a horseshoe and a bar magnet. Remember that the iron filings do not show the complete field of the magnet. The field actually extends out beyond the cardboard.

The Earth's Magnetic Field

Have you ever stopped to think that you are living in a magnetic field? Scientists believe that the earth produces magnetic effects as though it were a huge magnet. This means that the earth must have a magnetic field. You cannot see it, but you can see its effects. The compass that you use is in the earth's magnetic field with you. Its needle moves and points north and south because the field is strong enough to affect it.

The picture below shows you how scientists think that the magnetic field surrounds the earth. Do you see how the lines of force are concentrated at the magnetic poles?



The earth's magnetic field is strong enough to affect iron objects which it surrounds. You can see this by testing an iron radiator with a compass. Hold a compass close to the top of a radiator. Does this attract the north pole of the compass needle? Then move the compass to the bottom of the radiator. You will find that the part of the radiator closest to the ground repels the north pole and attracts the south pole of the compass needle. The bottom of the radiator has the same effect as the north pole of a magnet. This is because the radiator has been magnetized by the magnetic field of the earth.

The Sun and the Earth's Magnetism

We have known for a long time that there have been changes in the earth's magnetism from year to year. In fact, there are changes during the course of one day. We have learned of these changes because each day the compass needle wanders back and forth by a very small amount.

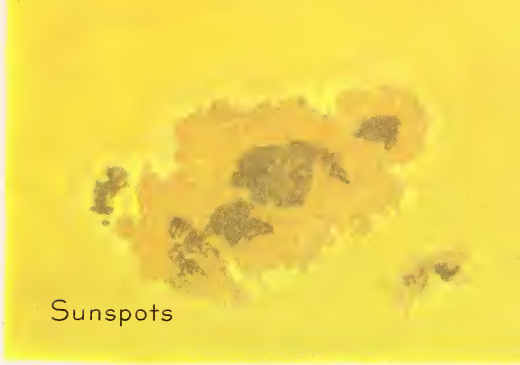
The change in the direction of the needle is so small that a person using a compass would not even notice it. But scientists in special laboratories are able to observe the changes as they take place.

These scientists have found that the north pole of the compass needle turns a trifle toward the east when the sun rises. During the latter part of the day it wanders a bit toward the west as the sun sets. After the sun sets, the needle resumes its normal position.

At times there is a still greater change in the needle's direction. It is believed that these changes have some connection with spots on the surface of the sun.

Sunspots are thought to be giant cyclones, or whirlpools, in the sun. No one is sure why or how they are caused, but they seem to have a profound effect on the earth's magnetic field.

It is believed that huge quantities of electrons are shot out from these spots on the sun. Many of these electrons speed from the sun to the earth. When they reach the earth's atmosphere, they sometimes produce the glow which is known in the Northern Hemisphere as the aurora borealis, or northern lights. Sometimes such violent disturbances take place in the earth's magnetism that they are spoken of as magnetic storms.



Sunspots

Man has much to learn about the magnetism of the earth. We have been able to make use of it, but we do not yet fully understand it. We know that it has some connection with the energy of the sun. There may be new discoveries about magnetism which will take place during your lifetime.

Northern lights

LEARNING MORE ABOUT THE EARTH'S MAGNETISM

1. You might try an experiment using the earth's magnetic field. You will need a hammer, a large iron nail, and a compass.

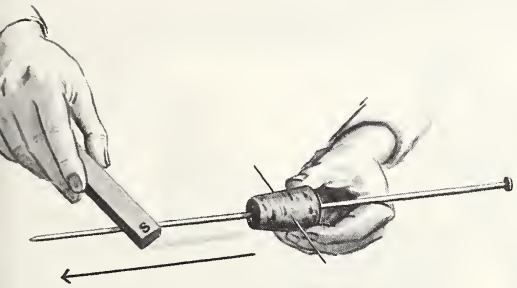
Hold one end of the nail near the north pole of the compass needle. Do the same with the other end of the nail. Is the north pole of the compass needle attracted to both ends of the nail? Now hold the nail in a north-south direction tilted toward the ground, as you see in the picture. Strike the head of the nail with the hammer several times. Then bring the other end of the nail near the north pole of the compass needle. If your experiment has been successful, the needle will move away from this end of the nail. The nail has become magnetized by striking it as it is held in the earth's magnetic field.

2. Your class might like to invite an airplane pilot to your classroom. Ask him about the latest types of compasses. You might also ask him how he uses a compass when flying.

3. Look at the picture at the foot of page 207. Do you see how the lines of magnetic force dip toward the earth? You can find out how the earth's magnetic field is slanted where you live. To do this, you will need to make a special type of magnetic needle. You will need a steel knitting needle, a cork, two darning needles, and two drinking glasses.

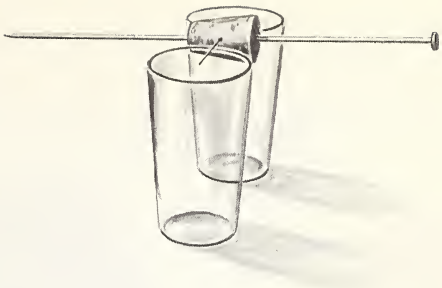
Put the knitting needle through the center of the cork. Stick the point of one darning needle into the

side of the cork. Put it exactly in line with the knitting needle. Do the same with the other darning needle on the opposite side of the cork. Rest the darning needles on the edges of two glasses so that the cork is suspended between them, and the knitting needle is pointing toward the north. Now adjust the knitting needle in the cork so that it balances in a horizontal position as you see in the picture at the right.



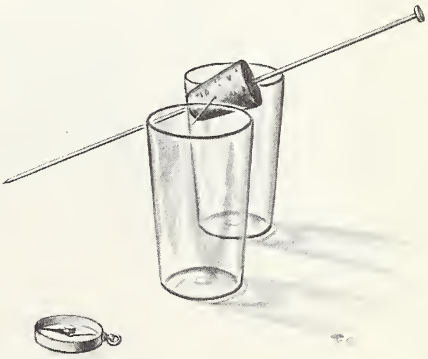
To magnetize the knitting needle, use the south pole of a bar magnet. First, pick up the cork carefully, taking care not to disturb the position of the needles in the cork. Now stroke the knitting needle in one direction with the magnet.

When the needle has become magnetized, you can test it to find which end has become its north pole. Bring one end of the magnetized needle



near the north pole of a compass needle. Is the compass needle attracted, or repelled? The north pole of the magnetized needle will be the end which repels the north pole of the compass needle.

Now replace the darning needles on the glasses so that the north pole of the magnetized needle points toward the north. If you have replaced it carefully, the north pole of the knitting needle will dip toward the earth. This will show you how much the magnetic field of the earth dips where you live.



Machines to Direct Energy

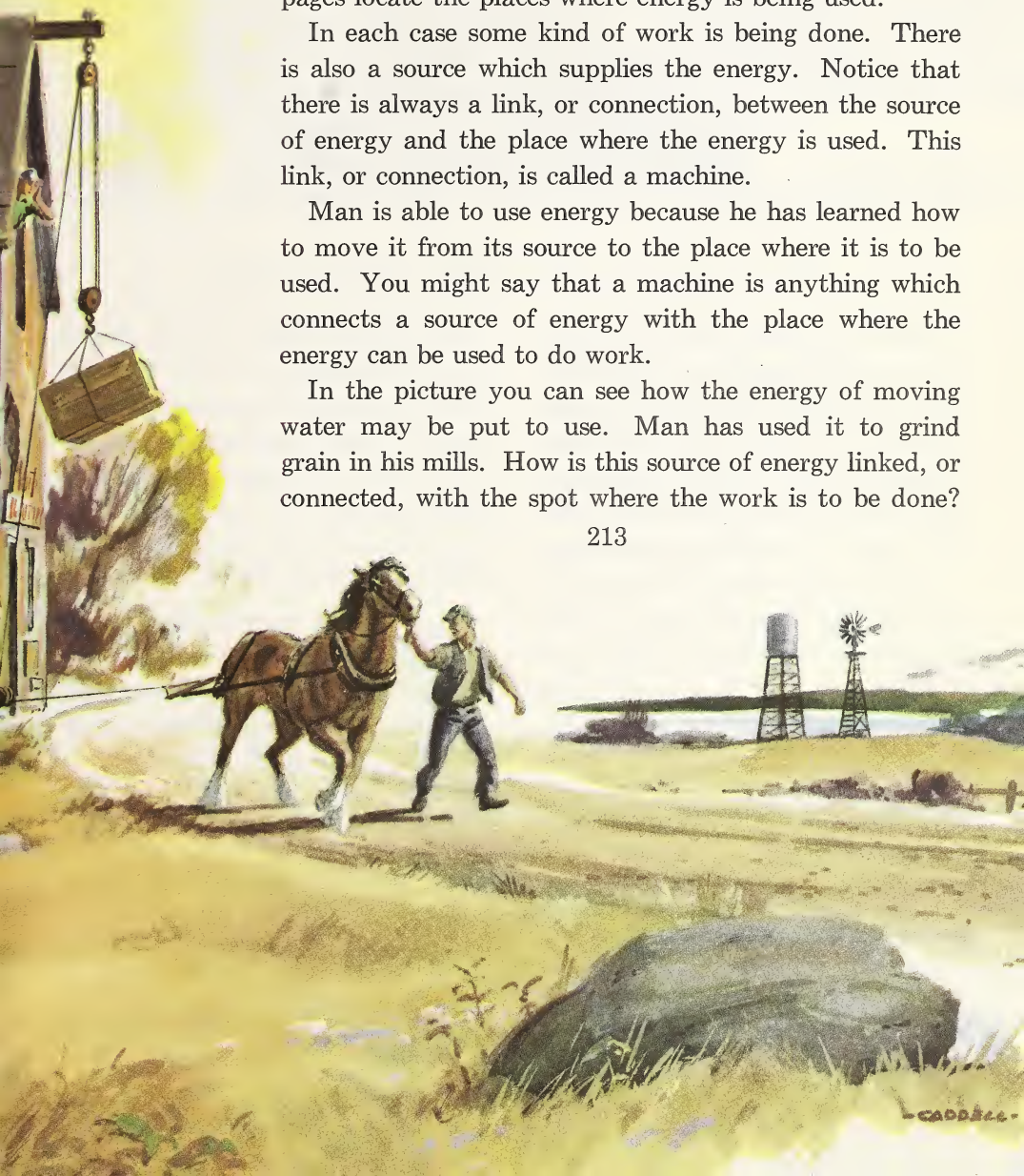
What Is a Machine?

As you look around, you can see many ways in which man has put energy to use. In the picture on these two pages locate the places where energy is being used.

In each case some kind of work is being done. There is also a source which supplies the energy. Notice that there is always a link, or connection, between the source of energy and the place where the energy is used. This link, or connection, is called a machine.

Man is able to use energy because he has learned how to move it from its source to the place where it is to be used. You might say that a machine is anything which connects a source of energy with the place where the energy can be used to do work.

In the picture you can see how the energy of moving water may be put to use. Man has used it to grind grain in his mills. How is this source of energy linked, or connected, with the spot where the work is to be done?



Man Learns to Use His Own Energy

There was a time when people had no man-made machines to help them. The only energy which early people could put to work was their own muscle energy. But you might say that they did have a machine which they used. It was the human body.

As you know, the food which you eat develops chemical energy in the muscles of your body. When you wish to do work, you must direct your muscle energy to the place where the work is to be done. If you wish to move a rock, you may direct your muscle energy to this work by placing your arms against the rock. So the body can be called a machine because it connects energy with the place where the energy is used to do work.

The human body is really a very fine machine, but at first it was the only machine that men had. With only the body machine to use, you can imagine how difficult it was just to keep alive.

Building to Direct Energy

As early man worked from day to day, there was very little that he could do to make his work less difficult. Everything to be done required the use of his own energy.

During his daily travels a man may have noticed that it was difficult to walk up the steep side of a certain hill. One day he may have found that it was easier to move up a side of the hill which had less of an incline, or slope. It was an impor-

tant discovery when man found that it was easier to move along a gradual incline than a steep one.

Even after such a discovery was made, it probably was many years before anyone realized that he could build an inclined path. It may have happened in this way: A large cave may have been found in the side of a cliff. Perhaps the entrance was too high above the ground to be reached. In order to examine the cave, men may have piled rocks below it. It would not be easy to climb these rocks to get in and out of the cave. Someone may have suggested adding to the pile of rocks to make a longer, more gradual incline.

Then as the incline was used, ways of improving it may have been found. Perhaps the incline was lengthened so that it would be more gradual. Small stones may have been used to fill in between the larger stones. This would make a smoother path. Soil may have been packed on top of the stones to make travel over the inclined path easier.

An inclined path has come to be called an inclined plane. When early man first made and used an inclined plane, he had invented a machine. An inclined plane is a machine because it connects a source of energy with the spot where work is to be done. The source of early man's energy was his own muscles. At first the work to be done may have been just to lift himself to high places more easily.

Inclined planes

However, after man had learned to build an inclined plane, he was able to use his energy to do many things which had been impossible before. Objects which could be moved along the ground, but were too heavy to lift, could now be raised. This could be done by building an inclined plane to the desired height. Then instead of having to lift a heavy object, a man would only have to push it along the slope.

An Inclined Plane Helps

You have probably seen and used an inclined plane many times. You may have ridden your bicycle up a hill, and you surely have climbed a flight of stairs. You probably realized that it was easier to climb a gradual slope than a steep one. But perhaps you did not realize that a flight of stairs and a road going up a hill are both machines. They direct your energy so that the work of climbing to a particular height is made easier.

Here is an experiment some boys did: They loaded their wagon with rock and had it weighed on a large scale at a lumber yard. The weight of the loaded wagon was 100 pounds.

One of the men at the lumber yard was able to lift the loaded wagon 1 foot from the ground. He had to use a great deal of muscle energy to lift it. The boys were not able to

lift the wagon, but they found another way to raise it above the ground. To do this, they first built a platform of dirt a bit wider and longer than the size of their wagon. The height of the platform was 1 foot.

Then the boys got two wide planks. One board was 3 feet long and the other was 5 feet long. A board was placed at each end of the dirt platform, as you see in the picture, to form an inclined plane. The inclined plane formed by the 3-foot board was steeper than that formed by the 5-foot board.

The boys fastened a spring balance to the handle of the wagon and took turns pulling the wagon up the 3-foot board. They pulled just enough to keep it moving up the board. The scale on the spring balance indicated that they were pulling with a force of about 34 pounds.

Then they repeated the experiment, but this time they pulled the wagon up the 5-foot board. They found that they had to pull with a force of only about 20 pounds to move the wagon up the longer board. It was easier to pull the wagon up the longer board than the shorter one because the longer, more gradual slope allowed them to spread the work out over a greater distance.

When the man lifted the wagon, he pulled with a force of 100 pounds for a distance of 1 foot. By pulling the

wagon up the 5-foot incline, the boys were able to pull with a force of only about 20 pounds, but they had to pull the wagon a longer distance. When they pulled with a force of about 20 pounds a foot for a total of 5 feet, they had to use about the same amount of muscle energy as the man. They were able to use their energy more slowly, however, and to spread out the work they had to do.

Later the boys tried the same experiment with a different wagon. When this wagon was loaded, it too weighed 100 pounds. But when the boys pulled this wagon up the two inclined planes, they found that they had to pull with a somewhat greater force than before. They decided that the amount of friction that had to be overcome made the difference. There was more friction when the second wagon was used than there had been with the first. But it still was easier to pull the wagon up the gentle slope than the steep one.

You might say that you can't get out of using energy. You can use a machine, such as an inclined plane, to do a little work at a time. It makes the work seem less difficult, but in the end you use the same amount of energy. Of course the machine also allows you to do things you might not otherwise be able to do.

Man Concentrates Energy

In addition to the inclined plane, early men invented other ways of making their work less difficult. No one knows exactly when or how these discoveries were made. Another important discovery may have been made at about the same time that men were learning to use the inclined plane.

Perhaps men were moving rocks to build an inclined path. Someone may have pushed with a stick at a rock that would not move. The stick may have slipped and become lodged under the rock.

As the stick was pulled to free it, the rock may have moved. Such a happening would have been truly astounding. Probably the stick was pushed under the rock again in order to find out whether this really would cause the rock to move. Now each time a man had to move a heavy rock he could use a stick to make the work less difficult. With it he could move rocks which he had not been able to move before, even with all the energy that he could muster. To this early man the stick must have seemed to multiply his energy.

A stick used in this way has come to be called a lever. A lever does not really multiply energy. Instead it concentrates the energy in one spot. You might say that the lever gathers the energy so that the greatest possible amount of work can be done with it. All the energy necessary to move the rock was in the muscles of that early man. The muscle energy of the man really moved the rock. The lever allowed the man to direct and concentrate his energy so that it would be at the right place at the right time.

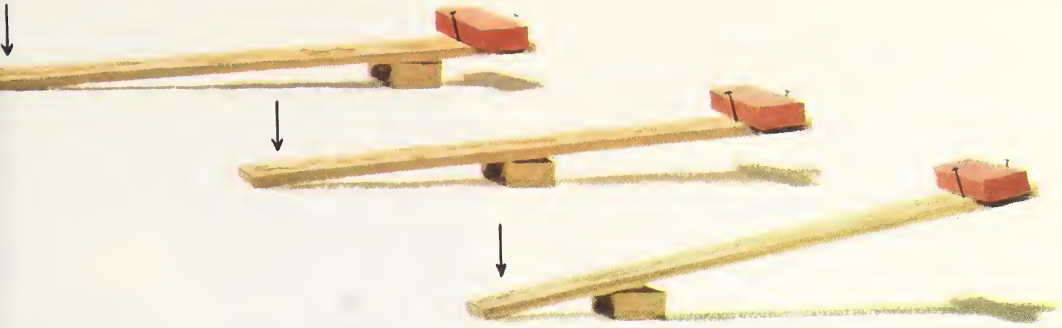
How Levers Work

Like the inclined plane the lever is a machine which connects a source of energy with the spot where work is to be done. The following experiments may help you to understand how levers work. You will need a board about 3 feet long, 3 inches wide, and $\frac{3}{4}$ inch thick. You will also need a block of wood about 6 inches long, 4 inches wide, and 2 inches thick. In addition you should have some nails and a brick.

After you have gathered your materials, place the brick on one end of the board. Drive two small nails into the board on each side of the brick as you see in the picture. Hold the brick in position and place the board so that its center is over the block of wood. Now use the board as a lever by pushing down on its upper end. The brick will rise into the air. You are lifting the brick by using your muscle energy.

You might push down on the board again and ask someone to measure the distance through which the brick moved. Then let the brick down on the table again and measure the distance from the table to the upper end of the board. This will show you how far your hand moved. You will need to keep a record of these two figures.

The point where the board rests on the block of wood is called the fulcrum of the lever. How well a lever works depends partly upon the

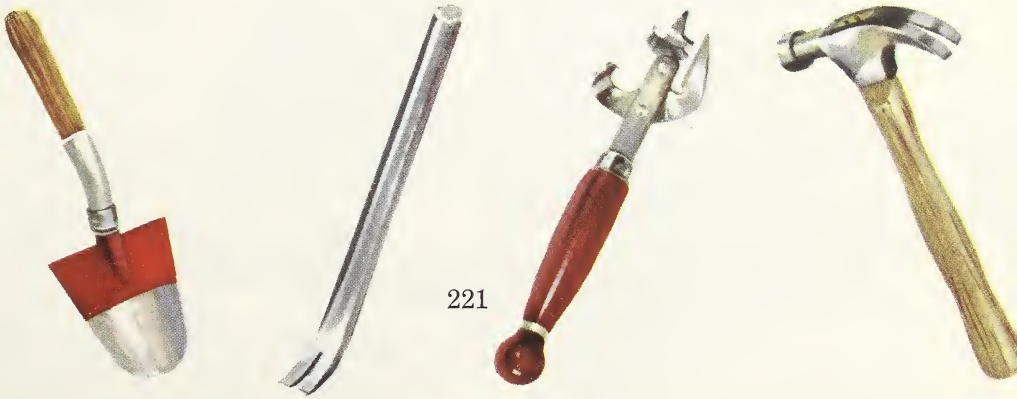


distance of the fulcrum from the source of energy and from the work to be done. When your hand and the brick are about equally distant from the fulcrum, you will probably find that they move about the same distance through space.

Let's change the distances between the brick, the fulcrum, and your hand. Move the block of wood so that it is halfway between the center of the board and the end where you put your hand. Now the brick is farther away from the block of wood than your hand is. Lift the brick again to the same height as before. Is it more difficult to lift this time? Notice that although the brick has moved as far as before, your hand has moved through less space.

You can experiment with the block in different positions. You will find that when the brick is nearer the block of wood than your hand is, your hand will move farther through space. This spreads the work out and makes the brick easier to lift.

In the picture below are several different levers you may have used. Look for the source of energy and the fulcrum in each. What is the work to be done?



Man Reduces Friction

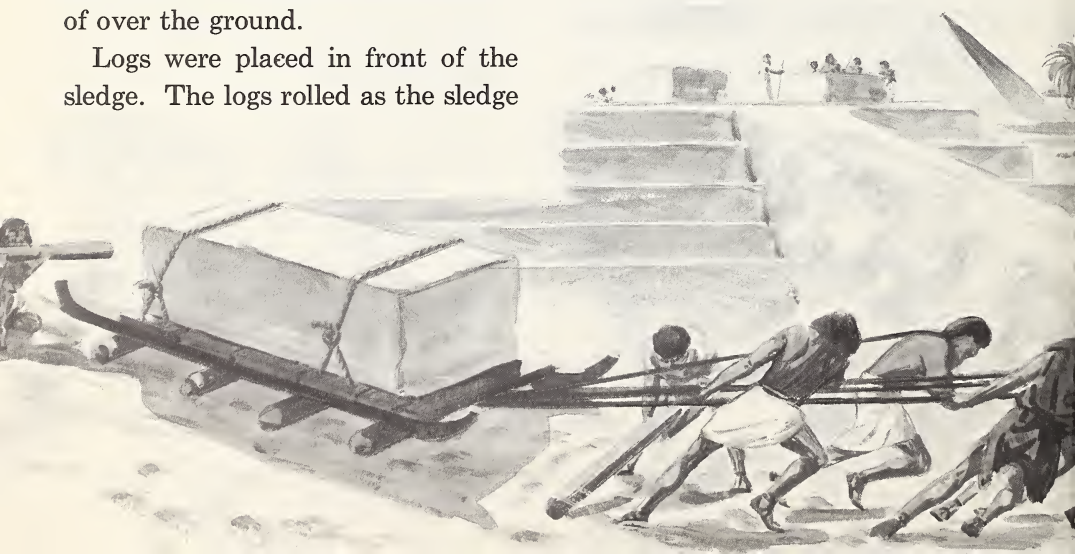
Both the inclined plane and the lever were basic machines used by early men to make work less difficult. But it still took a great deal of muscle energy to move things along the ground or on an inclined plane.

Part of early man's day-to-day work was hunting for food and gathering firewood. Probably his next big invention came from the desire to make this work less difficult. Someone may have found that it was easier to move food or firewood when it was piled on branches of trees which had been tied together. It was less difficult to pull things on this crude sledge than to carry or drag them over the rough ground.

The sledge was one of man's early attempts to reduce friction. His next successful attempt was when he pulled the sledge over logs instead of over the ground.

Logs were placed in front of the sledge. The logs rolled as the sledge was pulled over them. After the sledge passed over them, they were picked up and put in front of it again. This had to be done many times as the load was moved along. Even though it was slow, hard work, it was easier to use log rollers than to drag huge loads over the ground.

For many years men used a sledge and rollers to move heavy loads. Gradually, over a long period of time, changes were made in the rollers. It was found that a log with a wide diameter made a sledge move more easily than a log with a small diameter. It was very difficult to handle large logs. So the larger logs were cut into disks and these were attached to each end of a smaller log. The wide diameter of the large disks made rolling easier.



In the picture above you can see how a small log would be raised by the addition of a large disk to each end. At first each disk was attached to the log so that when the disk turned, the log also turned. The log would have to be replaced in front of the sledge after the sledge had been pulled over it.

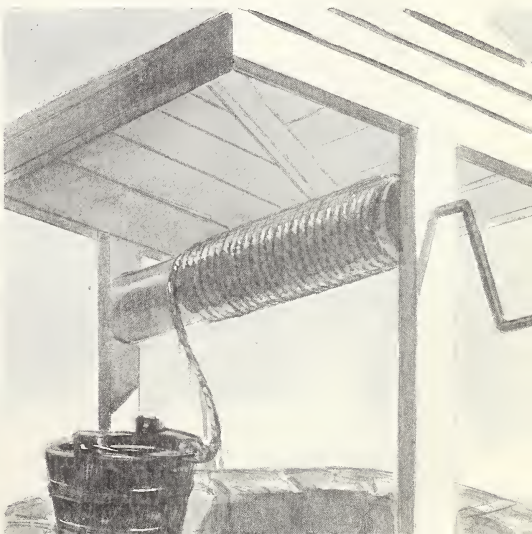
You have probably thought that this combination of disks and log looks very much like wheels and an axle. You are right! It took a long time, however, before someone realized that the disks could be attached so that they were free to roll whether the log turned or not. Then the log could be fastened to the sledge. These disks were the first crude wheels. No doubt they were heavy and bumped along the road, but it was easier and quicker to move the load when wheels were used.

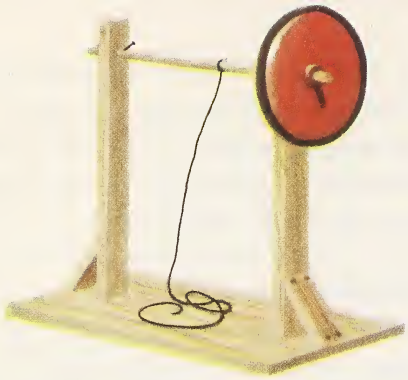
Today much of our daily living is affected by this early invention. Wheels play a major role not only in our transportation, but in our homes and factories as well.

A Windlass

In the picture below you can see a kind of wheel and axle called a windlass. It can be used to lift a bucket of water from a well. A complete turn of the wheel causes the rope to wind once around the axle. As the wheel turns, the bucket comes nearer the top of the well. To lower the bucket, the wheel is turned in the opposite direction.

You might make a windlass with which to experiment. You will need a wooden base and two pieces of wood about 24 inches long for the side pieces. For the wheel of the



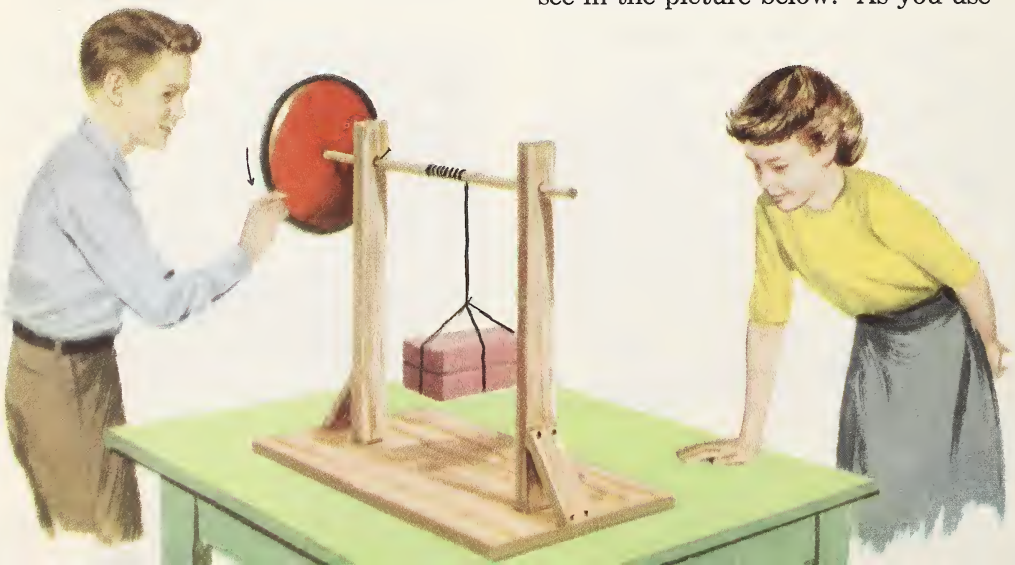


windlass you can use a disk of wood or a discarded wheel from a wagon or bicycle. A wooden rod such as a piece of a broomstick will serve very well as the axle. It should be about 18 inches long. You will also need some nails, rope, and two bricks.

First, bore a hole about 2 inches from one end of each of the wooden side pieces. Make the holes large enough for the wooden rod to move freely in them. Next nail these pieces of wood to the base in an upright position, just as you see in the picture at the left.

A wheel should be attached to one end of the rod so that when the wheel turns, the rod also turns. Now insert the rod in the holes which you bored. It would be a good idea to drive a nail part way into the rod on each side of the upright pieces. These will keep the rod from slipping through the holes. Then fasten a piece of rope to the rod with a nail. Turn the wheel several times to wrap some of the rope around the rod.

Now the windlass is ready to use. You can raise books or other weights with it by attaching them to the rope. Tie two bricks together and attach them to the windlass, as you see in the picture below. As you use



your muscle energy to turn the wheel of the windlass, the bricks will be moved upward. Of course you know that the wooden rod forms the axle of the windlass. Each turn of the wheel raises the weight one turn of the axle.

You can try an experiment with a second wheel. One wheel should be larger than the other. The diameter of the larger wheel should be about twice that of the smaller. As you can see in the picture, the small wheel is attached to one end of the rod and the larger wheel to the other end.

Now you can raise the bricks by turning either one of the wheels. Use the smaller wheel to raise them about 1 foot from the ground. Now use the larger wheel to raise them the same distance. Do you notice a difference as you turn the wheels? With which wheel is it easier to raise the bricks?

You may be surprised to find that it seems to be less difficult to raise the bricks with the larger wheel than with the smaller wheel. Hold your hand on the rim of the larger wheel and make one complete turn. Do the same with the smaller. To make one turn of the larger wheel, you must move your hand through a greater distance than when you make a turn of the smaller wheel. For each turn of either wheel the bricks are moved the same distance, because each raises the weight one turn of the axle.

Remember it takes a certain amount of muscle energy to raise the bricks 1 foot from the ground. You use the same amount of energy to raise them no matter which wheel you turn. If you use the larger wheel, you use your energy more slowly and over a longer distance. This makes it seem easier to do the work.

Experimenting with Basic Machines

We have read that early man invented the inclined plane, the lever, and the wheel and axle. These three are all basic machines. There are three other basic machines: the wedge, screw, and pulley. Each of these machines was invented thousands of years ago.

Most people usually call these the six simple machines. We have called them basic machines because all others are made by combining these six. The invention of the six basic machines gave man a way of directing and using his energy more effectively. These inventions are probably the most important which man has ever made.

Each of the six inventions took many hundreds of years to produce. Probably many men had a part in producing them.

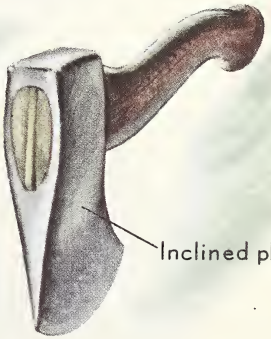
The Wedge

A wedge is one of the basic machines. You will be able to define it for yourself after examining one. Look at a knife blade. Press one side of the blade flat against a table. You can see that the blade slopes up from its cutting edge to form an inclined plane. Now turn the knife over and look at the other side of the blade. It too forms an inclined plane. A knife, then, has two inclined planes. It is a wedge.

All wedges work in the same way. They work by pushing and prying something apart. When you cut meat, the sharp edge of the knife opens the meat or pushes it apart. Then the inclined planes pry the two sides still farther apart.

In cutting down a large tree woodsmen use a wedge that they drive into the crack made by the saw. The sides of the wedge help to push the wood apart. Then it is easier to saw the tree. The ax you use in chopping down a tree or splitting wood for kindling is also a wedge. It would be very difficult to get these jobs done without the use of this basic machine.

Some wedges are easier to use than others. A long, thin wedge is used more easily than a short, thick one. You can find this out by making



two wedges and using them. Cut two wedges out of wood like the ones you see at the left. Wedge A and Wedge B should be the same thickness at the thick end. But Wedge B should be longer.

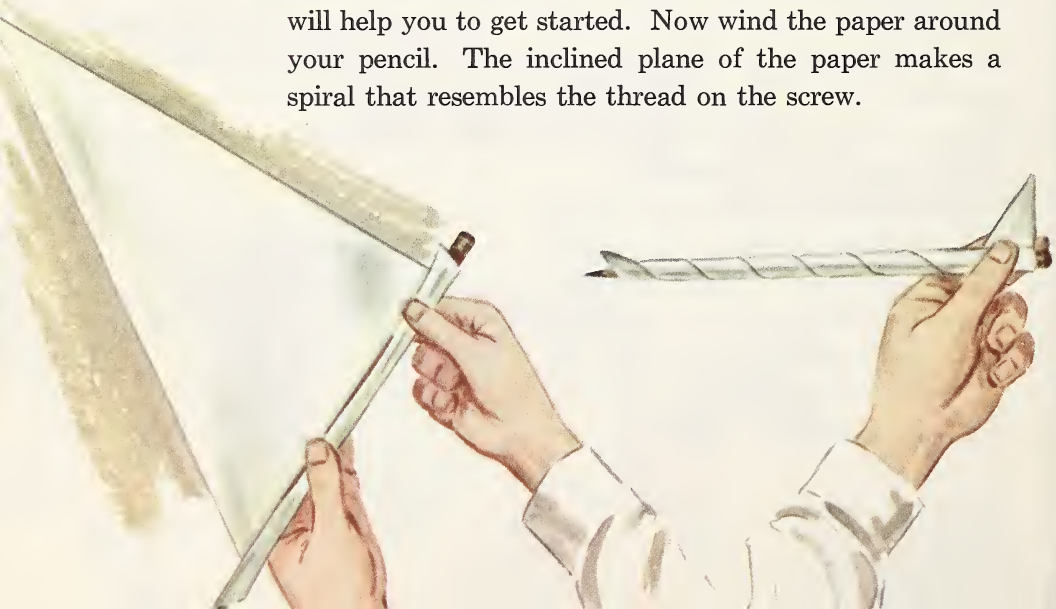
Take the two wedges out of doors and with a hammer pound them into the ground. You will find that it is easier to pound Wedge B into the ground. How would you explain this? Remember that the thick end of Wedge A is the same thickness as that of Wedge B.

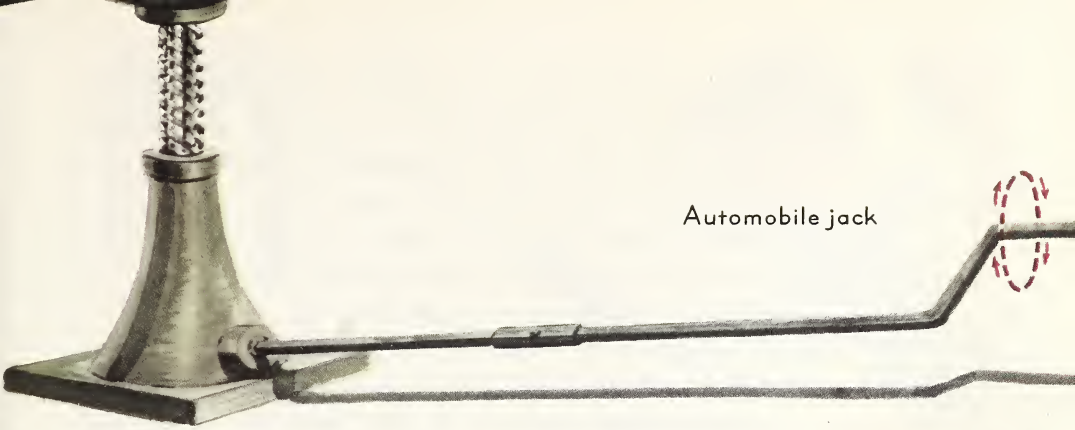
The Screw

If you look at a screw, you will see a tiny strip of metal that winds along it. This is called the thread. Here is something you might do to learn more about the thread of a screw:

Take a sheet of paper and draw a line from one corner to the opposite corner. Now cut along the line you have drawn. You will have two pieces of paper that have three sides each. One side looks like an inclined plane.

Hold the short side of one of the pieces of paper against the length of your pencil. The drawings below will help you to get started. Now wind the paper around your pencil. The inclined plane of the paper makes a spiral that resembles the thread on the screw.





Automobile jack

Look at a bolt and nut. You can see the thread winding around the outside of the bolt. Now look at the nut. The threads are inside the nut. Put the nut on the end of the bolt and begin turning it. It moves forward along the bolt. Now turn it in just the opposite direction. The nut moves backward.

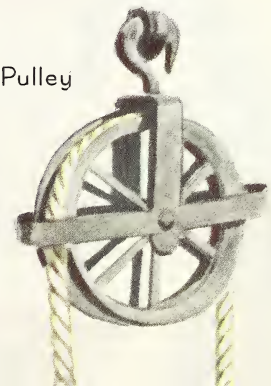
Some automobile jacks work in much the same way as the bolt and nut. The screw in the jack fits into a hollow tube. The tube has threads inside it, just as the nut has. The screw moves upward along the threads inside the tube. It moves in the same way as the nut moves forward on the bolt.

As the screw moves upward, it raises the car. To lower the car, you turn the handle of the jack in the opposite direction. The screw moves downward in the same way that the nut moves backward on a bolt.

The screw is a basic machine, which man has invented to direct his energy. When man uses the screw as a machine, he can direct energy in such a way that work seems to be less difficult.

How Pulleys Work

If you look closely at the pulley used in moving a flag to the top of a flagpole, you'll see a small wheel. The wheel has a rim on each side of it. This prevents the rope from



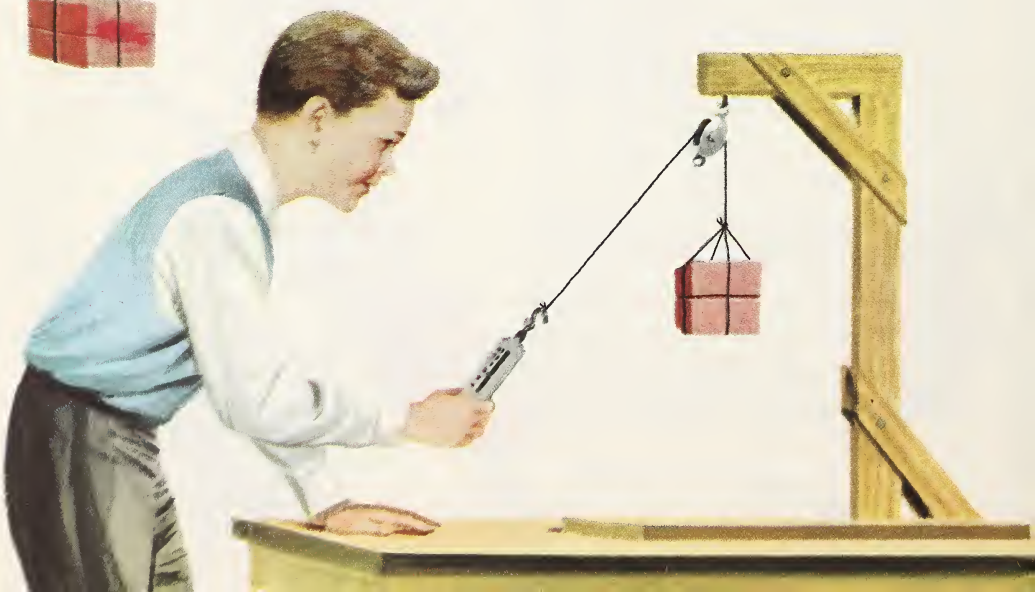
Pulley

slipping off the wheel. As the rope moves smoothly over the wheel, the wheel turns. If you wish to experiment with pulleys, first make a support like the one you see in the picture at the left. You may attach it to a wall or build a stand for it. Next fasten a pulley to a hook on the support. Put a rope over the pulley wheel. Now you are ready to begin your experiments.

Tie two bricks together and fasten a spring balance to them. Lift the bricks about 1 foot from the floor. Look at the spring balance to see how much the bricks weigh. This will tell you how much force you used in lifting them.

Then tie the bricks to one end of the rope you put over the pulley. Tie the spring balance to the other end of the rope, as you see in the picture below. Lift the bricks about 1 foot from the floor by pulling down on the spring balance. Notice that you have to pull the rope a distance of about 1 foot to lift the bricks 1 foot.

Read the weight on the spring balance. The weight is about the same as when you lifted the bricks without the help of the pulley. But when you lifted the bricks, you had to pull up. When you used the pulley, you



pulled down. Used in this way, the pulley is a machine with which you have directed your energy so you could pull down instead of up.

You will need to add another pulley to do the next part of the experiment. The picture at the top of the page shows how to use two pulleys. The rope is tied to the bottom of the single pulley. Then it goes down and around the second pulley. The rope then goes up over the wheel of the single pulley and is fastened to the spring balance. The bricks are fastened to the second pulley.

Now you are ready to lift the bricks. Pull the spring balance toward you. Lift the bricks about 1 foot from the floor, just as you did before. Look at the spring balance to see how much force it takes to lift the bricks. You will use about one half the amount of force you used before. But notice that you had to pull the rope twice as far.

In both experiments you lifted the bricks by using your own muscle energy. To lift the bricks 1 foot takes a definite amount of energy. So you used the same amount of muscle energy in both experiments. With the two pulleys the spring balance registered only half the force, but you had to use that force through twice the distance. So you use as much energy in the end. But the two-pulley system allows you to spread the work out and it seems less difficult.

Complex machine

Energy Where Man Needs It

Energy is most helpful when it can be moved to the place where it can be used to do work. Even man's own muscle energy would be of little value if he could not direct it by use of his body machine. The six basic machines give us ways of directing our energy. They allow us to do a little work at a time. When we spread the work out, it seems less difficult. Our energy is used to better advantage.

At first man used the basic machines to direct his own energy. Then by making combinations of these basic machines, he found that he could direct energy from other sources.

In time he became aware that he was surrounded by great quantities of energy. He felt the force of the wind. He saw the rush of moving water. He became aware that wind and water were sources of energy that he could use. To use them, he had to be able to direct the energy to the place where work was to be done.

A machine made by combining basic, or simple, machines is called a complex machine. With complex machines man is able to direct energy from many different sources to do his work. What basic machines do you find in the picture above?

LEARNING MORE ABOUT MACHINES

1. In the picture you can see a power shovel which man is able to use for many different jobs. As you can see, it is being used to remove soil, and with each scoop of the shovel a lot of work is being done.

What is the source of the energy which man is putting to work? How is he directing the energy to the place where the work is being done?

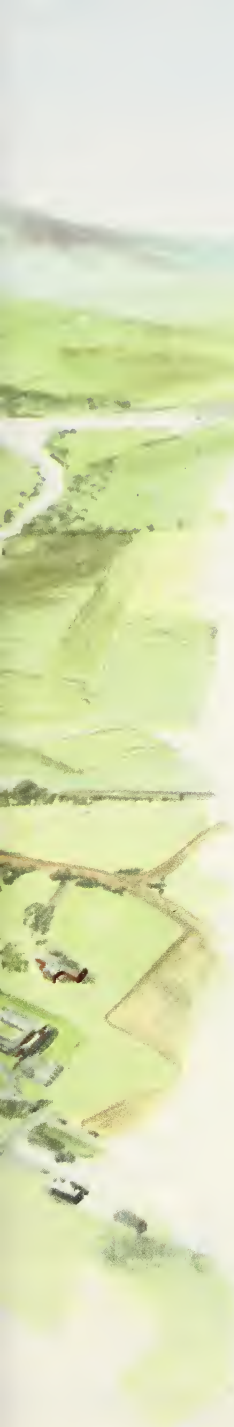
The power shovel is a complex machine which man uses to direct the energy from fuel to do work. What are some of the basic machines which have been combined to make this complex machine? You might begin by examining the shovel arm. What kind of basic machine is it?

2. Examine some other complex machines. What work is done with the machine? What is the source of the energy which is used to do the work? What combination of basic machines is used to direct the energy to the place where the work is done?

3. You might examine a pair of scissors and a nutcracker. Each of these simple machines is a lever. Where is the fulcrum and the source of energy? What is the work to be done?

4. A wheelbarrow is a combination of two basic machines: the wheel and the lever. Of course the wheel is easy to see. But can you find the lever?

The Earth's Airways and Beyond



Man and the Air Around

In recent years man has lifted himself from the ground! He has found ways of moving through the air.

Balloons, dirigibles, airplanes, helicopters, "jets," and rockets are all very familiar to us. Fifty years ago, however, during your grandfather's boyhood, many of these things had never been heard of.

Now almost everyone talks about flying. Whenever we look toward the sky, we may see an airship of one kind or another.

Man found a new freedom when he took to the air. High mountains, jungles, and wide seas had always made it difficult for him to travel. Trips from one part of the earth to another used to take long periods of time. Today, in some of our fastest airliners, it only takes a few hours to go from San Francisco to New York. As the air-traveler looks down from the sky, he sees a vast landscape made up of mountains and other obstacles, which used to make travel over the earth so difficult.

Airplanes—How They Fly

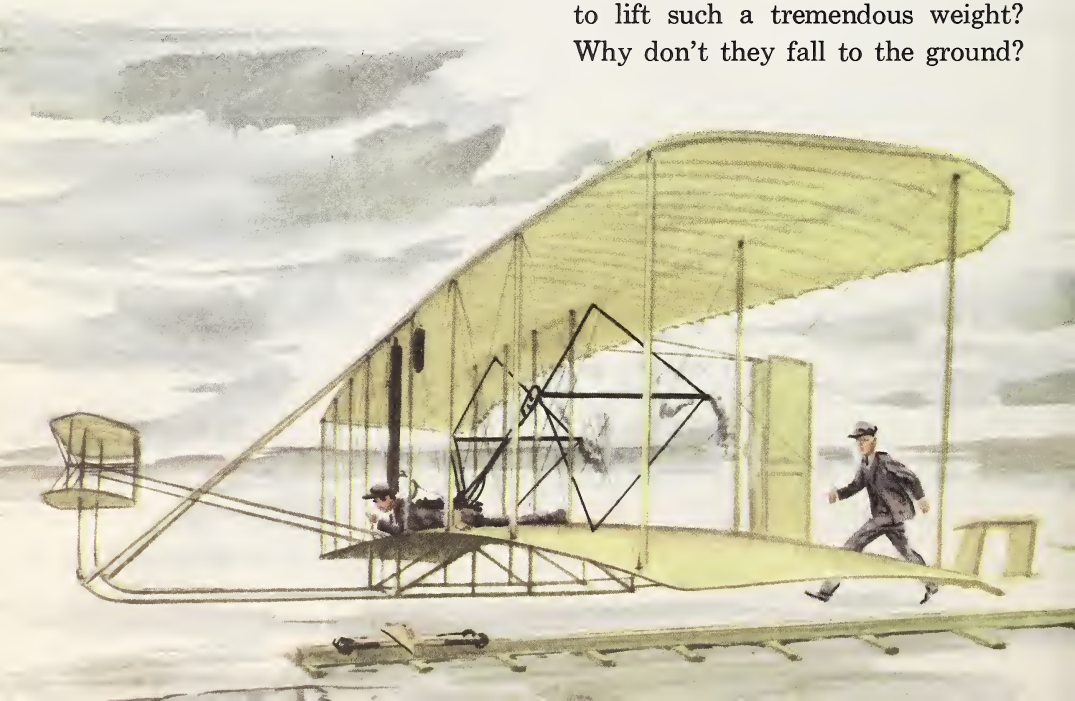
The first successful flight of an airplane took place in 1903. Two brothers, Orville and Wilbur Wright, were the men who made the flight possible. This great event took place at Kitty Hawk, North Carolina.

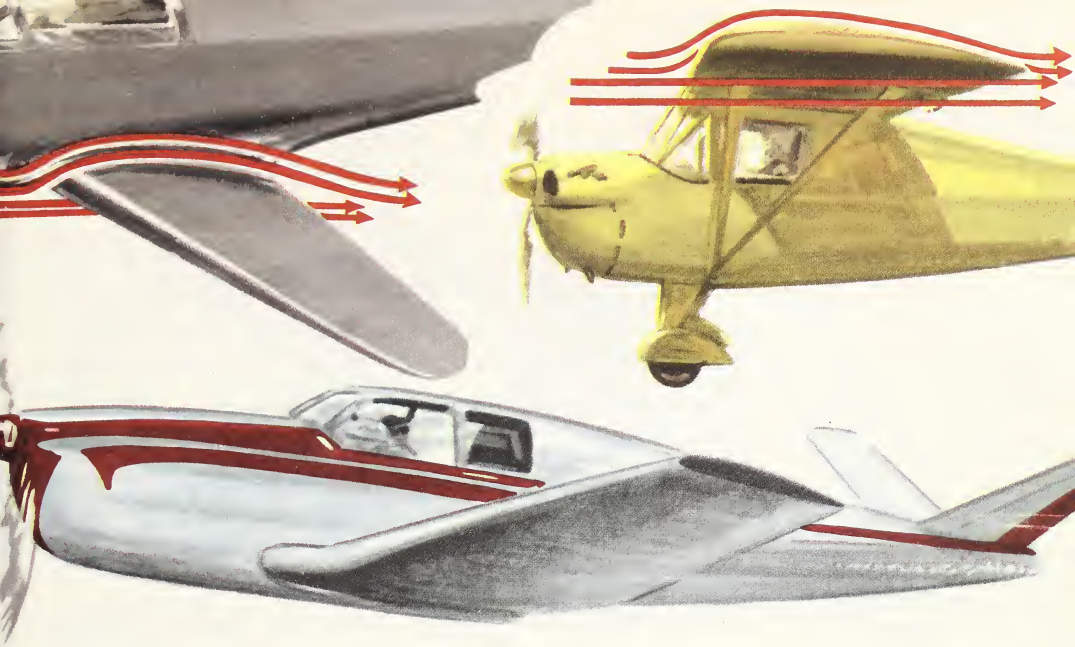
More than 100 years earlier, the first passenger balloon had been flown successfully. Balloons are able to rise above the ground because they are filled with gas that is lighter than air. Dirigibles too rise because the gas which they contain weighs less than the surrounding air.

The airplane flown by the Wright brothers differed greatly from previous aircraft. No lighter-than-air gas was used to lift this airship. In fact, this first successful airplane weighed about 800 pounds.

This was really a remarkable event! Here was something that was very heavy and yet it could move through the air. This seemed very difficult to understand. After all, people had long observed that anything heavy would fall to the ground unless supported; that is, anything except birds. However, birds weigh much less than 800 pounds.

Some of our present-day airliners weigh about 310,000 pounds when fully loaded. How are they able to lift such a tremendous weight? Why don't they fall to the ground?





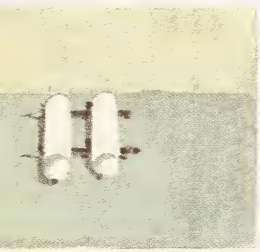
Air over the Wing

It is the wings of airplanes which make flying, as we know it, possible. Notice the shape of an airplane wing. The front, or leading, edge of the wing is thicker than its trailing edge. The top of the wing is curved, but the underside is almost flat. Each wing is attached to the fuselage in such a way that it tilts slightly, just as you see in the pictures on this page.

Air presses on all parts of the plane and wings. As the plane moves through the air, the curved edge of the wing slices the air. Some of the air flows over the wing. Another stream of air moves under the wing. We are told that both streams of air reach the back edge of the wing at the same time.

Look at the drawings on this page of an airplane wing. You can see that the distance over the top of the wing is greater than the distance under the wing.

The stream of air that goes over the top of the wing has farther to travel than the stream that goes below the wing. If both streams of air reach the trailing edge at the same time, the air over the top of the wing must travel faster than the stream of air passing under the wing.

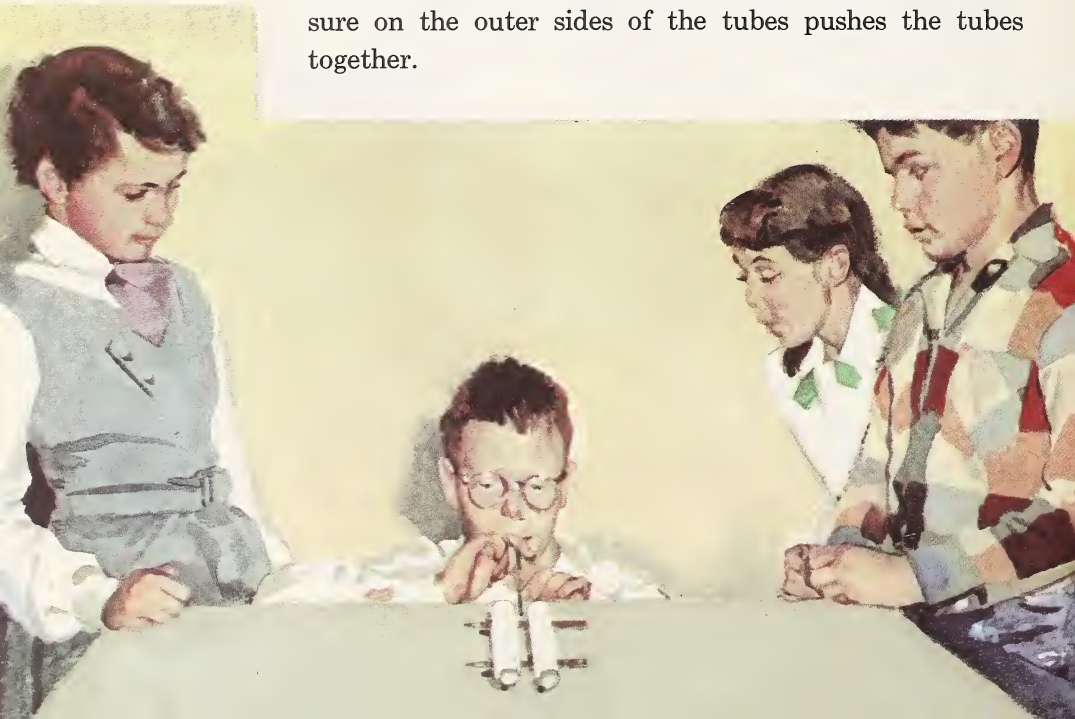


Air Loses Pressure

The stream of air that moves over an airplane wing loses some of its push, or pressure. This loss of push is brought about as the air begins to move faster.

To help you understand that faster-moving air has less pressure, you might do an experiment. You will need two pieces of paper each about 6 inches square, two pencils, and a soda straw. Paste the opposite edges of each square of paper together so that each will form a hollow tube. Lay the pencils on the desk about 3 inches apart. Place the paper tubes across the pencils about 1 inch apart, as you see in the picture at the left. Take the soda straw and blow between the two tubes. The two paper tubes roll together!

When you blow through the straw, the air moves rapidly between the paper tubes. The fast-moving air between the tubes has less pressure than the air on the outer sides of the tubes. The greater amount of air pressure on the outer sides of the tubes pushes the tubes together.



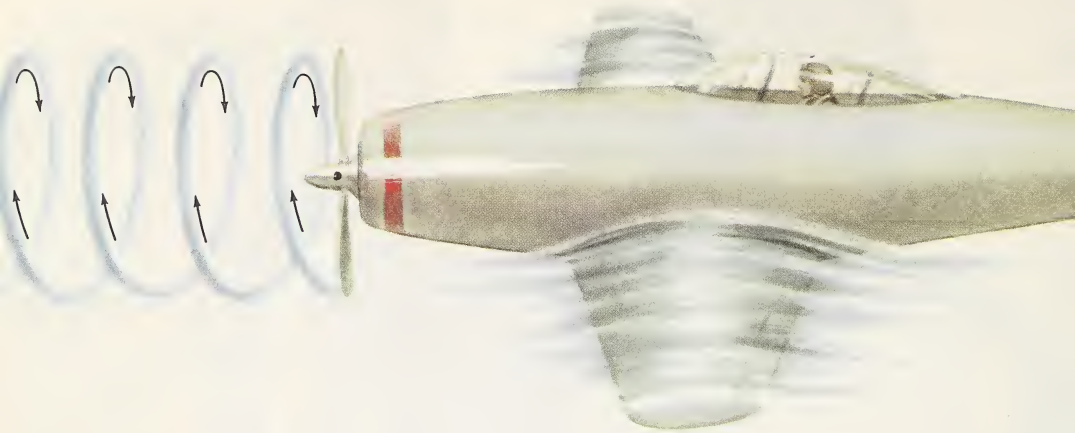
Air moves very fast over the top of an airplane wing. It moves under the wing more slowly. The air below the wing has more pressure than the faster-traveling air above. More pressure under the wing pushes the wing upward. When this happens, the wing lifts. We say that the force of lift helps to keep the plane in the air.

You might make a paper wing which will show how moving air helps to lift an airplane. Cut out a piece of paper about 2 inches wide and 6 inches long. Attach the paper to a wooden stand, just as you see in the picture. Notice that the unattached end of the paper wing will fall toward the ground.

Now blow across the top edge of the paper wing. Blow hard! Do you see how the wing rises? The faster you get the air going over the top of the wing, the more the wing will rise.

Vary the way you blow air over the wing. Blow hard, then blow more gently, and then increase your blowing again. As you do this, the wing will rise, go down, and then rise again.

You are really changing the air speed over the top of the wing. As you increase the air speed, the pressure on top of the wing is lowered. The greater pressure on the bottom of the wing pushes it up.



The Propeller

Of course an airplane does not only lift, but also moves forward. You might say that a plane is pulled forward through the air by its propellers. In fact, a propeller could be thought of as working much like a screw. Have you ever put a screw into a piece of wood with a screwdriver? As the screw turns, it is forced into the wood. The faster you turn the screw, the faster the screw goes into the wood.

Now think of an airplane. An engine of a plane turns its propeller much as a screw is turned. The blades of a propeller are twisted. The twisted blades slice through the air and force air toward the back of the plane. As the air moves backward, the plane moves forward. The faster the propeller spins, the faster it pulls the plane through the air.

The propeller has to turn rapidly and pull the plane forward along the ground before the wings lift. As the plane moves, much air passes over and under the wings. The faster the plane moves along the ground, the faster the air moves over the wings. When there is enough difference in the pressure of the air above and below the wings, the plane will rise.

So you see it is necessary for the plane to move forward on the ground before air moves fast enough over the wings to provide lift for the plane.

The force which moves the plane forward is called thrust. We have seen how thrust is created by a propeller turned by an engine. Let's see another way in which an aircraft can be thrust, or sent forward, through the air.

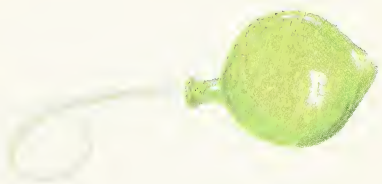
Jet Planes

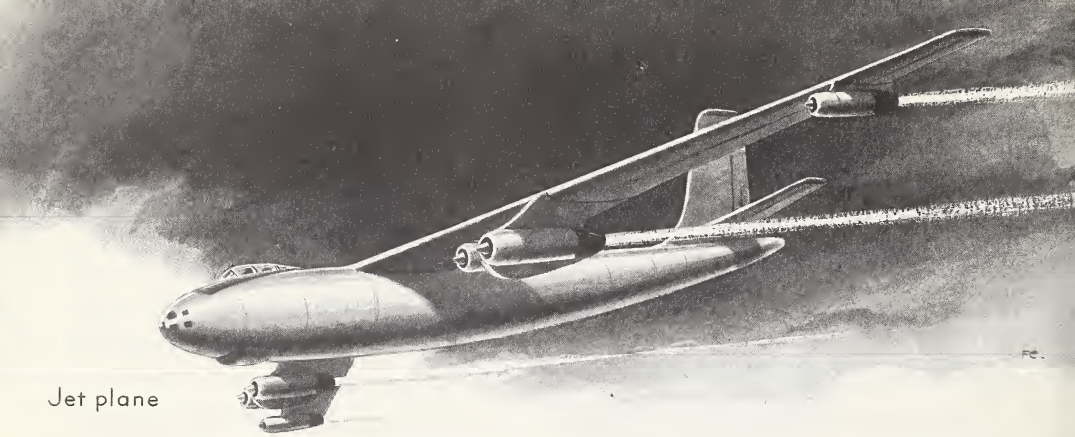
Perhaps you have heard the sound of a plane roaring overhead. When you looked up to see it, it was gone. You may have seen only some trails of vapor left behind. The plane you heard was probably a jet plane.

Many jet planes do not have propellers. Neither do they have gasoline engines as ordinary airplanes do. Yet they are thrust through the air at great speeds. Such planes receive their thrust from jet engines.

You can make something which resembles a jet engine by using a balloon. Blow air into the balloon. Then without fastening the balloon, throw it into the air. It will whirl around the room in jet-propelled flight.

A blast of air comes out through the opening in the balloon. This air pushes the balloon along. As the air rushes out from the neck of the balloon, there is a push in the opposite direction. As long as the air rushes



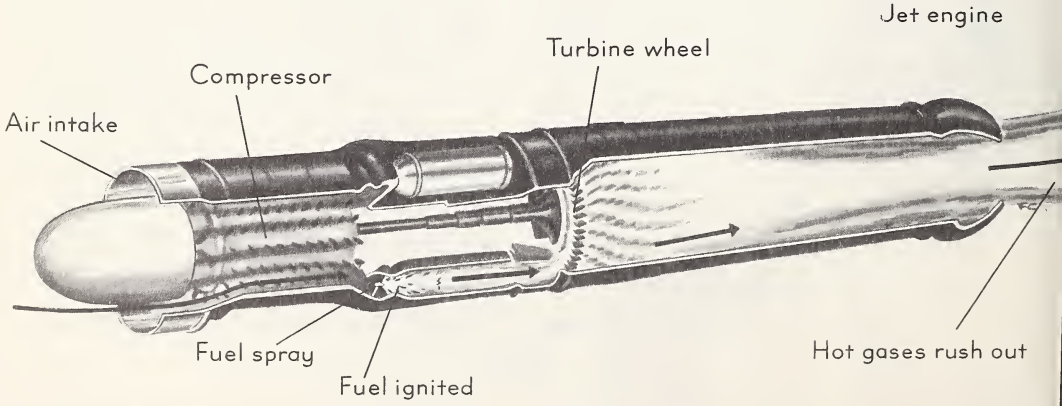


Jet plane

out of the balloon, the balloon keeps on moving through the air. Air rushes out in one direction, and the balloon moves in the opposite direction.

A jet engine pushes a plane forward in much the same way as the balloon was moved through the air. To get this thrust, a jet engine uses air from the atmosphere. The air is taken into the engine and is pressed into a small space, or compressed. Then some fuel, usually kerosene, is pumped into the compressed air. As the fuel burns, the hot gases expand very rapidly. They rush out through an opening at the back of the engine. This pushes the jet plane forward.

The hot gases provide thrust for a jet plane, just as the escaping air did for the balloon. They push a jet plane through the air at terrific speeds.



Some jet planes have traveled faster than sound. We usually say that sound travels about 760 miles an hour. Certain types of planes have traveled more than 1300 miles per hour.

Just think! At that speed it would take a little less than two hours to go from one coast of the United States to the other. You could leave New York at 8 A.M. one morning and arrive in San Francisco about 7 A.M. the same morning. Because of the difference in time between the two cities, you would arrive in San Francisco at an earlier hour than that at which you left New York.

Gravity and Drag

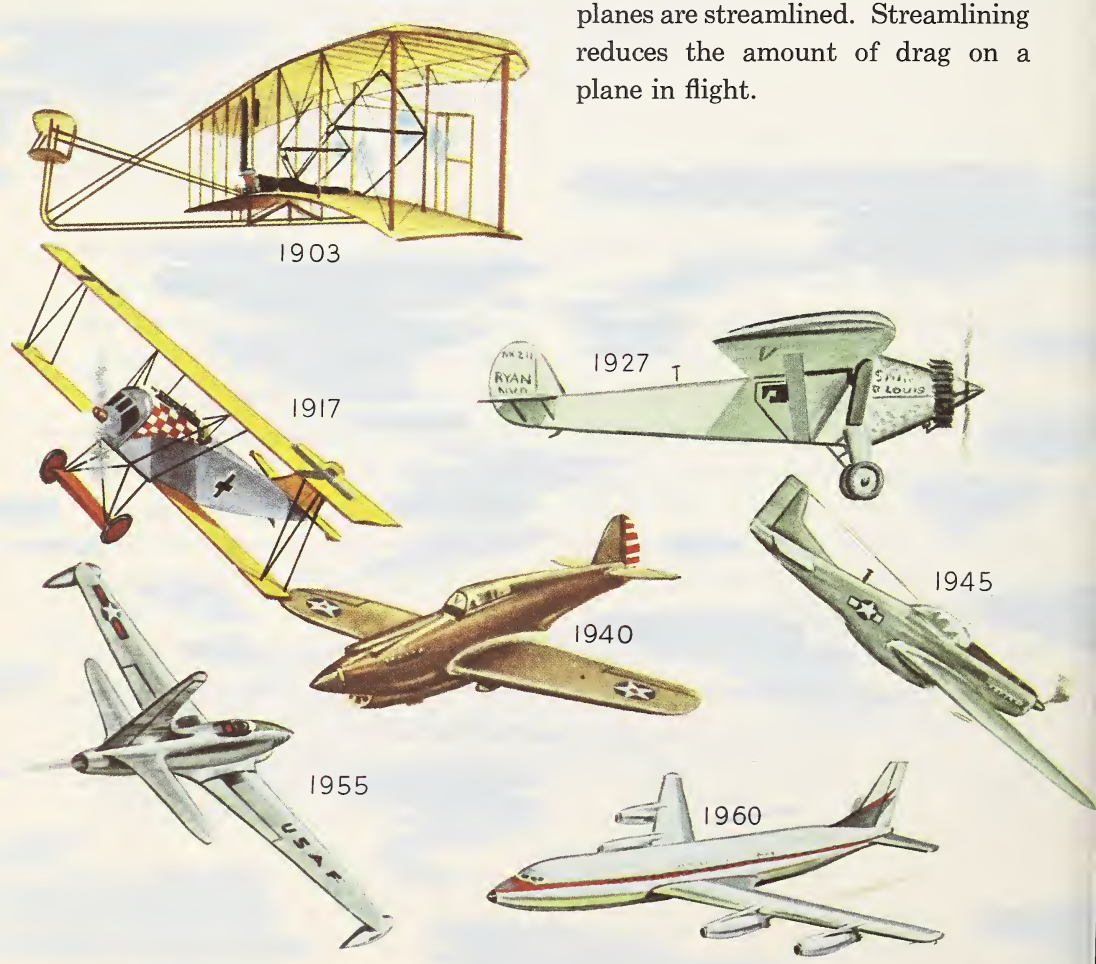
Another very important force that acts on a plane in flight is gravity. Gravity is the force which pulls everything toward the earth. Before man could fly in a plane that was heavier than air, he had to design a wing that would overcome the pull of gravity. The wings of a plane provide its lift.

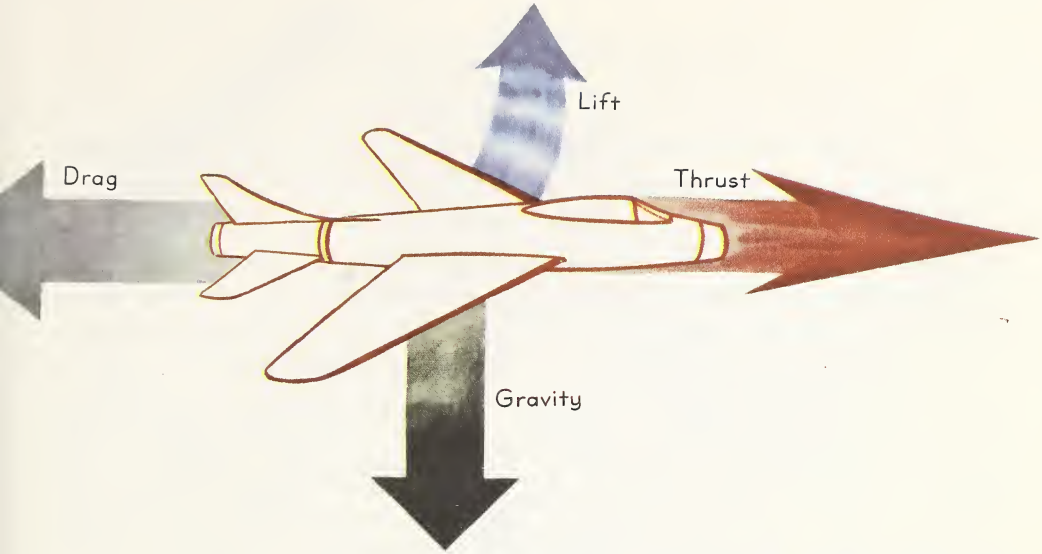
In order to stay in the air, a plane must be thrust forward. As long as it moves fast enough through the air so that the force of lift is stronger than the force of gravity, a plane

will fly. Whenever the force of lift becomes less than the force of gravity, a plane will sink to the earth.

As a plane moves forward, air rubs against the wings, the body, and other parts of the plane. There is friction between the air and all parts of a plane. The force of this friction is called drag. The more drag, the harder it is to thrust a plane through the air. For a plane to move forward in flight, the force of drag must be less than thrust.

There are some parts of the plane that do not help to lift or pull the plane. Today these parts are designed to lessen the amount of drag. Look at the different planes in the pictures below. These are some of the first planes and some that we use today. You can see that present-day planes are streamlined. Streamlining reduces the amount of drag on a plane in flight.





Four Forces

Look at the drawing of a plane on this page. It shows the four forces which act on a plane when it is flying. They are thrust and lift, drag and gravity. Thrust and lift must be stronger than the forces of drag and gravity if the plane is to fly.

Every plane has a slow-flying speed at which it can continue to move through the air. If a plane moves slower than this flying speed, the forces of drag and gravity become greater than the forces of thrust and lift. When this happens, the plane may begin to drop downward toward the earth. A crash may occur if the plane does not regain its flying speed.

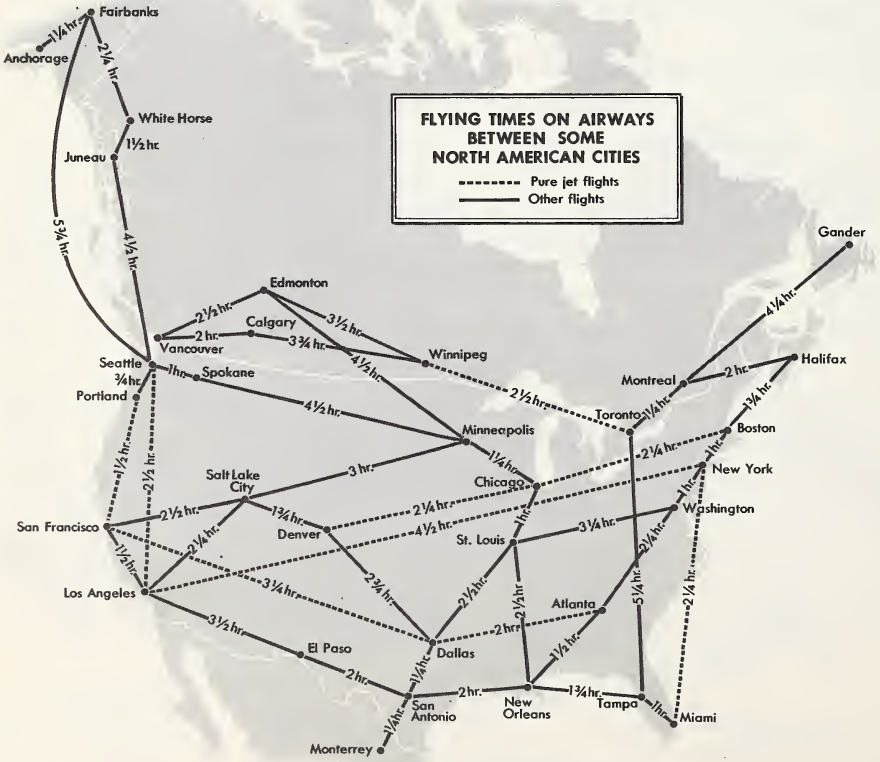
Careful balancing between these four forces provides the way to control the flight of a plane. As a plane is landing, a very delicate balance is maintained between these forces. The flying speed is continually decreased as the plane comes in for the landing. When the wheels are about to touch the runway, the pilot points the nose of the plane up slightly. This increases wind resistance and slows the plane still more. With the help of the forces of gravity and drag he is able to settle the plane gently on the runway. The plane is no longer flying as it moves along the runway. It has landed.

Airways from Here to There

The map on this page shows some of the routes that planes travel. Each airway is marked with a certain number of hours. This indicates the time it takes large passenger planes to travel between the two cities connected by the airway.

Notice that some airways show flying times by jet planes. Compare these times with those of other planes on shorter routes. Of course the flying time on any of these airways depends on the speed at which the planes can be flown. As planes improve, the flying times will change also. You might like to compare the times on this map with those on a recent airline timetable. Don't forget about the various time zones when you are computing flying times. Why is this important?

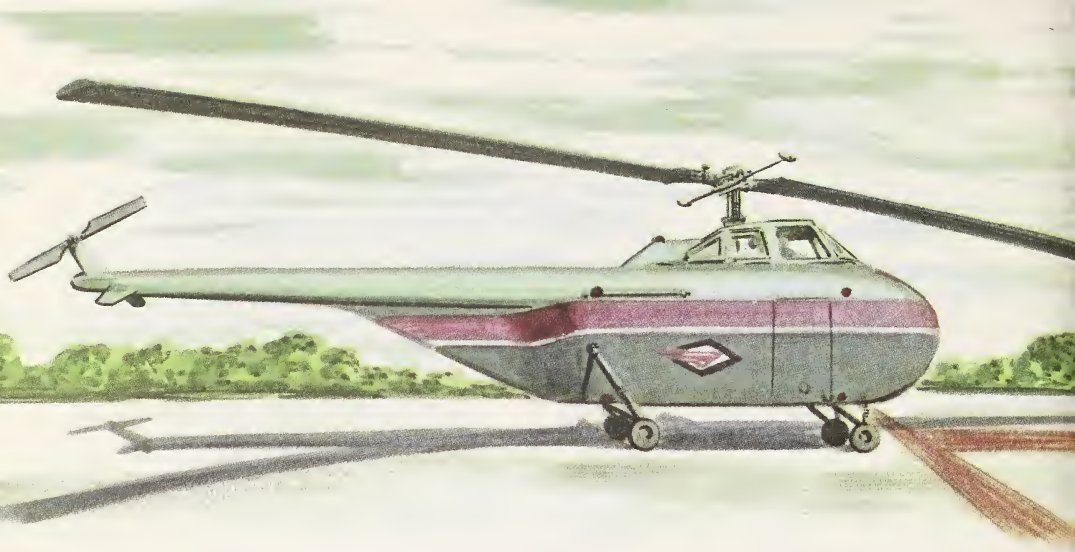
In the United States and Canada there is an airport within a few miles of almost every large city. From north to south, east to west, the airways link our cities.



The map above is a global map. You will see that the air miles between some of the cities have been marked. Over thousands of miles of airways, we can fly a plane to any part of our earth.

Imagine that you are piloting a plane from Anchorage to Amsterdam. Suppose your plane could fly at a speed of 1000 miles an hour. How many hours might it take you to reach Amsterdam?

As flying speeds increase, it takes less time to travel between these cities, even though the distance remains the same. We might say that the faster our planes are able to travel, the smaller the earth becomes.



Helicopters Have Moving Wings

Most of the aircraft that we are familiar with have wings attached to the body of the plane. You might say that the wings are fixed. They don't rotate or move along or around the plane.

The aircraft on this page is called a helicopter. Look at the blades above the body of the helicopter. They turn round and round. They are really movable or rotating wings.

The rotating wings give to the helicopter special qualities. You have probably seen a helicopter hovering above one spot. It looks as though it were suspended in the air! The air moving over the rotating wings of the helicopter provides enough lift to just overcome gravity. The aircraft neither falls nor rises. It remains suspended!

The pilot of a helicopter can move it forward and backward and sideways by regulating the moving wings. The helicopter can also be moved up and down somewhat like an elevator.

We usually call a specially prepared area where airplanes take off and land an airport. But have you ever heard the word *heliport?* A specially prepared area from which helicopters take off and land is often called a heliport.

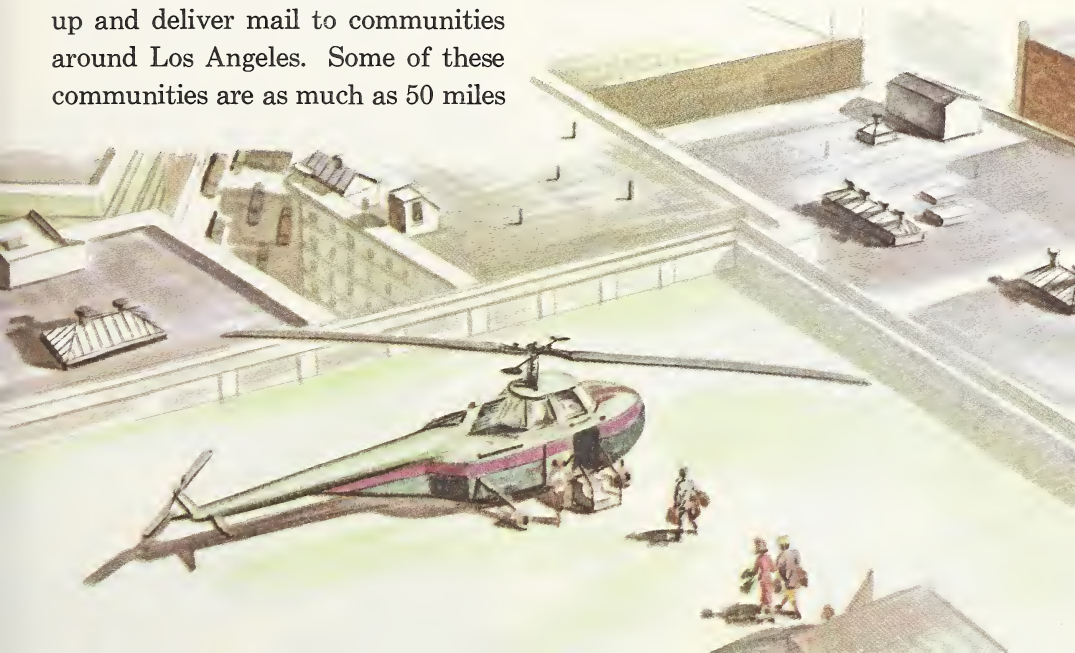
Heliports are much cheaper and easier to build than airports. A heliport also requires much less space. It can very easily be located on the roof of certain types of buildings.

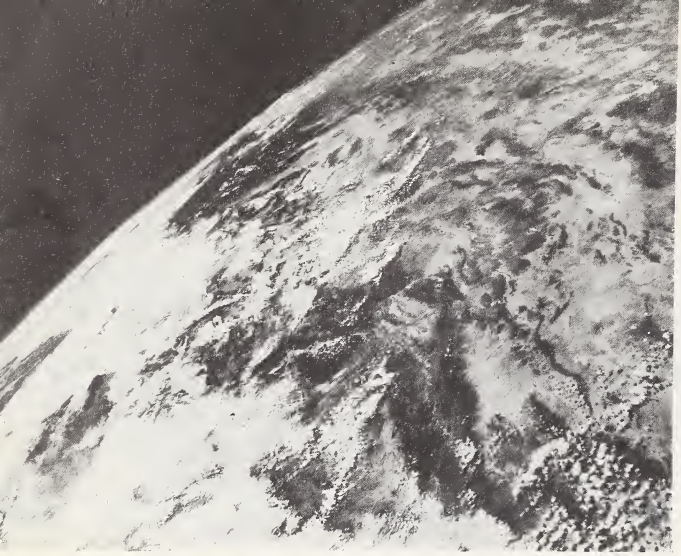
Helicopters are of use in many different ways. Again and again they have proved their value in emergency rescue work. They also have many day-to-day uses. For instance, in Los Angeles, California, helicopters are being used in the mail service. During the day there are flights by helicopter from the main post office to the airport. The Los Angeles post office is located in the business district. The helicopters take off and land on the roof of the post-office building.

Helicopters are also used to pick up and deliver mail to communities around Los Angeles. Some of these communities are as much as 50 miles away. Much time is saved by using this helicopter service.

This same type of mail service is used in Chicago and New York. In New York the helicopter service carries passengers as well. Passengers are carried between major airports in and around New York. There is helicopter service between Newark airport in New Jersey and Idlewild and La Guardia airports in New York.

Helicopters are also being used to carry passengers and mail between large cities in Europe. In the future much of the travel between nearby cities and towns may be done by helicopter. There may be a heliport in every town!





About 600,000 square miles of the earth are shown in this photograph made from a rocket at 155 miles

Into Space—Beyond Our Earth

Zoom into outer space! Off to the moon!

In 1959 for the first time an earth satellite circled the moon. A picture was taken of the other side of the moon. You may have seen it.

Each time a satellite is sent into space, man learns something. But there are still many problems to be solved as we move out into space.

Up and Up

At just a few thousand feet above sea level we may encounter some of the same difficulties that we would face in outer space. The higher we go, the less oxygen there is in the air.

Our bodies need a certain amount of oxygen if we are to remain healthy and active. At high altitudes there is so little oxygen in the air that it becomes difficult to breathe. Many people become dizzy and short of breath when they are at heights of about 11,000 feet or more. This can happen right here on earth.

Some people can get along fairly well on the oxygen that is in the air up to a height of 20,000 feet. Explorers have even been able to breathe the air at altitudes as high as 26,000 feet. But usually they carry extra supplies of oxygen with them at high altitudes.

Many planes fly at heights above 20,000 feet. Some of the larger passenger planes on long runs make regular flights at altitudes above 30,000 feet. In order for passengers to live at this height, special equipment is needed. In commercial passenger planes today there is a way of supplying oxygen to the passengers and crew. We say that these planes are pressurized.

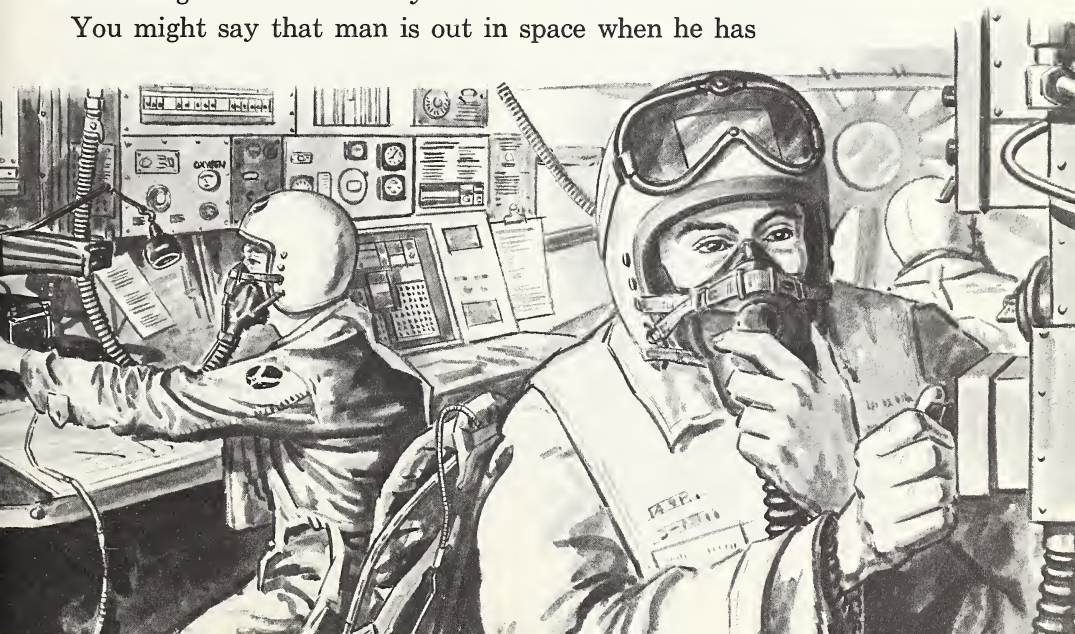
Men in the Air Force use oxygen equipment much like that which you see in the pictures on this page. They are required to use this equipment when flying at high altitudes. Then they will surely have enough oxygen to breathe.

Man Out in Space

Men called astronauts are being trained to go far out into space beyond our atmosphere. Perhaps you have heard of them. You might discuss some of the problems still to be solved concerning astronauts.

Man does not have to go very far from the surface of the earth before he is out in space. Maybe you have never thought of it in this way.

You might say that man is out in space when he has



reached a height at which there is not enough oxygen for him to breathe. At altitudes above 50,000 feet man cannot get enough oxygen from the air to keep himself alive. At these heights he would die in about 15 seconds if he did not have special oxygen equipment.

Pilots who fly in aircraft above 50,000 feet wear special flying suits. In the picture below you can see a pilot prepared to fly at high altitudes. His suit is airtight. You might say that he carries his own atmosphere with him. Inside the suit there is enough oxygen for him to breathe. The part of the suit next to his body remains at a temperature which keeps him comfortable.

As we go into outer space, we must make sure that it is possible to remain alive. Otherwise, travel in outer space will not be practicable. Many things have already been done to overcome this problem. But there is still much to be learned.

Aircraft Out in Space

As we go farther and farther from the earth's surface, the decrease in oxygen in the atmosphere makes traveling difficult. Not only do we need oxygen to breathe, but the engines that push our aircraft through space need oxygen also.

Many planes have gasoline engines. These engines must have oxygen so that the fuel will burn and supply the energy which powers the plane. Jet engines also use oxygen from the air to burn their fuel. Difficulties arise as these planes go farther and farther from the earth's surface. At high altitudes there is not enough oxygen in the atmosphere for the fuel to burn.

Both the gasoline engine and the jet engine will stop operating at high altitudes. At heights of only 70,000 feet, or about 13 miles, neither of

Douglas Skyrocket

these engines operates well. As man goes beyond this altitude, other types of engines must be used to supply the power needed to keep the aircraft moving through space.

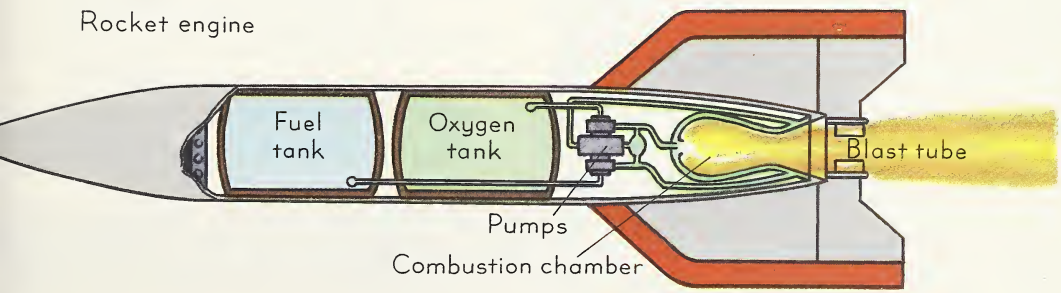
Rocket engines have been developed, which carry their own oxygen supply. They do not depend upon the oxygen in the atmosphere. A rocket-powered aircraft called the Douglas Skyrocket has reached an altitude of 15 miles. Even as you read this, other planes are probably going higher. Each day brings new advances.

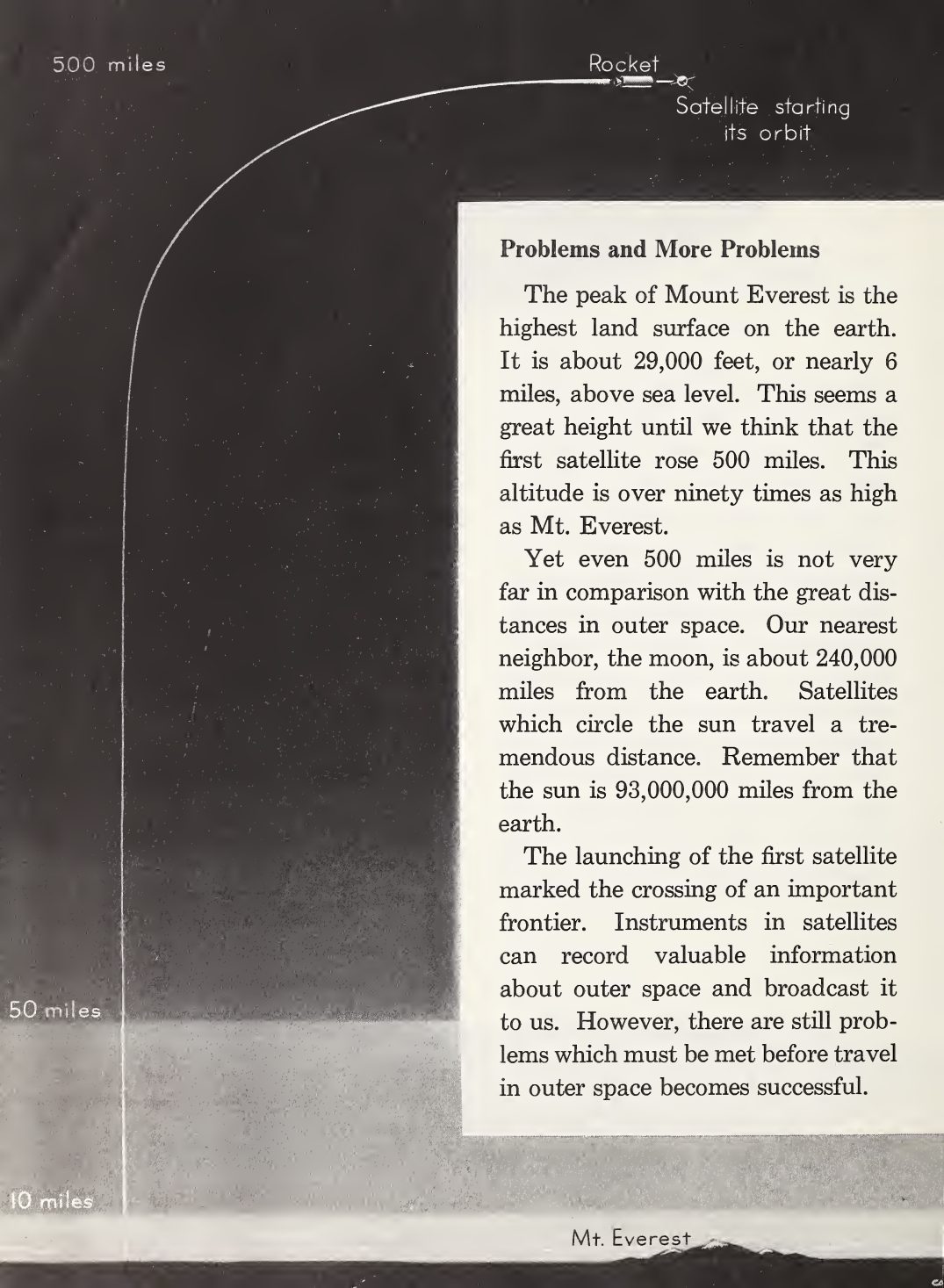
Rockets without pilots have risen to extremely high altitudes. In 1957 the first of many man-made moons, or satellites, were launched from rockets. The first satellite circled the earth at a height of about 500 miles. Other satellites and rockets have gone much higher.

On March 11, 1960, a 94-pound satellite called Pioneer V was put into orbit around the sun. The satellite was lifted into orbit by a rocket 90 feet long.

This satellite had solar cells and a radio transmitter. Messages from the satellite were sent back to earth. In this way man is learning about conditions in outer space.

Rocket engine





Problems and More Problems

The peak of Mount Everest is the highest land surface on the earth. It is about 29,000 feet, or nearly 6 miles, above sea level. This seems a great height until we think that the first satellite rose 500 miles. This altitude is over ninety times as high as Mt. Everest.

Yet even 500 miles is not very far in comparison with the great distances in outer space. Our nearest neighbor, the moon, is about 240,000 miles from the earth. Satellites which circle the sun travel a tremendous distance. Remember that the sun is 93,000,000 miles from the earth.

The launching of the first satellite marked the crossing of an important frontier. Instruments in satellites can record valuable information about outer space and broadcast it to us. However, there are still problems which must be met before travel in outer space becomes successful.

Men and women interested in space travel are at work developing new fuels to give greater power to rockets. To escape from the gravitational pull of the earth, a spaceship must travel at about 25,000 miles an hour. This takes a great deal of fuel. Once this speed has been reached, the ship could "coast" through space toward its destination. But it would need additional fuel to come in for a landing. And to return to earth, still more fuel would be needed.

Heat will also be a real problem. Space craft will become very hot as they leave and re-enter our atmosphere at tremendous speeds. Then, too, heat from the sun will increase as man moves farther and farther out into the darkness of space. Radiation from particles sent out by the sun will also be a danger to man.

There will probably be many other problems which will arise with each new step. For instance, there is the question of how food and drink can be supplied to space travelers. Sufficient oxygen, too, will be a necessity for man in outer space. No one can tell what all the problems will be. How they will be met and solved depends on how wise and intelligent we are.

A whole new world awaits us as we attempt greater and greater journeys into space. No one knows what we shall find. But this we do know—exciting things are happening. We are on way!

LEARNING MORE ABOUT FLIGHT

1. Many people have helped aviation develop. You might like to read about Charles Lindbergh, Amelia Earhart, Wiley Post, Jimmy Doolittle, and Eddie Rickenbacker.

2. You might plan to visit an airport near your town. One of the places you should get permission to visit is the traffic control tower.

3. Many changes in living have taken place because of the airplane. How would our world be different if there were no airplanes?

4. You might build a model airplane. Some boys and girls build and fly models with engines.

5. Find out more about satellites. Look for names such as Vanguard, Discoverer, Pioneer, Explorer, Tiros. What satellites are in orbit now?

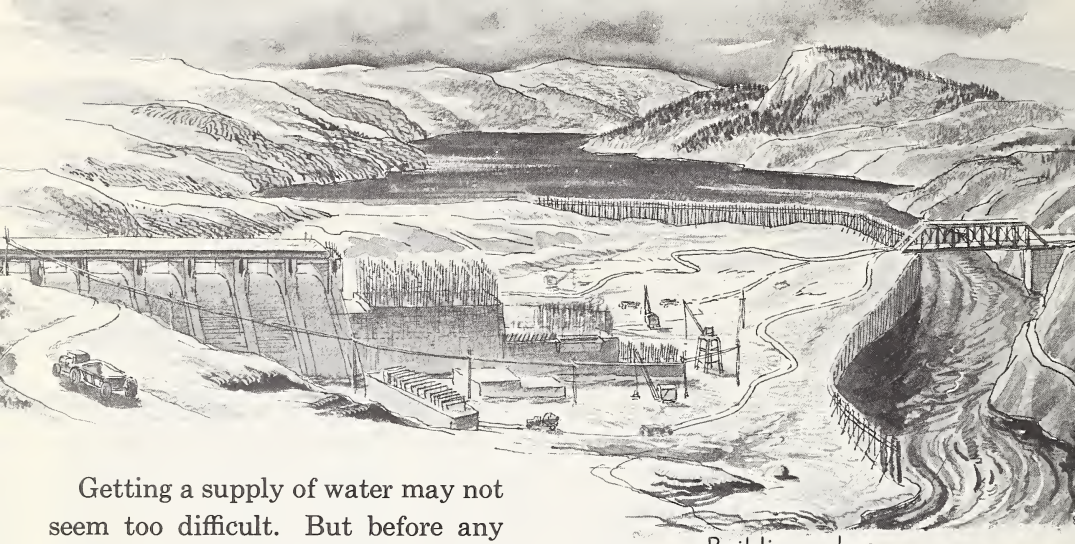
Making the World a Healthful Place

The Community Around You

All you may need to do to obtain water to wash your face in the morning is to turn a faucet. When you have finished washing, the soapy water runs down the drain. It runs through pipes out of your house and maybe even out of your community. Perhaps you have never stopped to think where the water comes from and where it is going.

When you have finished eating your breakfast, there may be some scraps of food remaining. Perhaps there are some orange peels or an eggshell. These food scraps are probably put in the garbage can. You may have seen a truck come to your home to collect garbage, but what then? Where is the garbage taken in your community and how is it disposed of?

Perhaps you live in a large city. One of the biggest problems facing any large community is where and how to obtain a good supply of water. You and everyone else in your city must have water for drinking, bathing, cooking, and many other purposes.



Building a dam

Getting a supply of water may not seem too difficult. But before any water can reach a city home, many plans must be made. A source of water must be found large enough so that everyone in the city can have enough water to use. It is also important that the water should be clean and pure. When you turn a faucet in your home and are supplied with pure water, you know that your city has solved this problem.

The drains which carry away water after you have used it are another way in which your community is meeting a health problem. How to dispose of garbage and other waste materials are still other problems which a city must solve. Yes, much must be done in a large community to make it pleasant and healthful.

Perhaps you live in a small community or even on a farm. Here the problems of a pure water supply and of disposing of waste materials may not be faced by the community as a whole. Each householder may have to find his own solution.

Often we are not aware of the many things necessary to our community's health. Communities are not all alike and their answers to their problems are different also. There are several possible solutions and some are better than others. When a community is clean and pleasant and healthy, it usually means that its problems have been intelligently solved.

The Water You Drink

"Rain, rain, go away!" But if the rain goes, we shall have less water to use. During times of little rainfall we are sure to hear talk about our water supplies.

All our water supplies are the result of rain, snow, sleet, or hail. Much of the water that falls from the skies moves along the surface of the ground. It may flow into creeks and rivers. It may even collect in bodies of water such as ponds and lakes. This water which moves along or collects on the surface of the land is called surface water. It is a source of water easily available to us. But surface water is easily polluted. We have to be very cautious about using surface water.

Some of the water which falls on the land sinks into the soil. Here part of it may be used by plants. As water moves down into the soil, it may collect below the surface of the ground. This water stored in the soil and in certain layers of rock below the surface is called ground water. Sometimes ground water moves through the ground and reappears on the surface as a spring.

Ground water may be made available for use if wells are dug or drilled. As water is drawn from underground sources, the supply is gradually lowered. But all the while, water falling on the surface of the earth moves down through the soil or rock to add to the supplies underground. We must take care that we do not use our supplies of water faster than they can be refilled. We are always looking for better ways of collecting and storing the water which falls on the earth.

Artesian Wells

Perhaps you live in a town or a city which gets its water supply from a river, a mountain stream, or a lake nearby. Or the city you live in may bring its water by pipes from a reservoir built many hundreds of miles away. Instead of using surface water, some cities draw their water supplies from underground. The wells from which much of this water comes are called artesian wells.

Many country homes too obtain their water from these sources. Water from artesian wells will usually flow to the surface without the need of pumping. These wells yield a supply of water which is much purer than most surface water. However, the presence of an artesian water supply in any region depends upon very special rock conditions.

To have an artesian water supply, there must be three separate layers of rock below the surface of the soil. The middle layer must be a kind of rock that has many tiny spaces in it. Rock of this sort is said to be porous. Water will move easily through porous rock. Above and below the porous layer there must be layers of nonporous rock. These keep the water trapped in the porous layer.

There is another condition to be met if the porous layer is to be an artesian supply. In the picture below, do you see how the layers of rock are tilted? At its upper end the porous rock is exposed. It is able to soak up rain and melting snow. The force of gravity moves the water through the tilted porous layer. Artesian wells may be drilled to the porous layer at some point

below the exposed end. There will be enough pressure to bring the water to the surface.

Sometimes artesian wells are thousands of feet deep. In many dry regions of the earth artesian water is the only source available for irrigation. Parts of the Sahara Desert have been made to bloom because of water from artesian wells. It seems hard to believe that below such a sandy, hot desert as the Sahara there is water—water trapped in porous rock. It is there for the taking. With it man can turn the desert into a productive garden.

Here is something you might do which will help you to see how water rises in an artesian well: You will need a large tin can, a piece of rubber tubing about 3 feet long, and some bricks. First, make a hole in the bottom of the tin can and insert one end of the tube in the hole. Close the other end of the tube with a cork or some clay. Clay or plasticine may also be used to seal the fitting between the tube and tin can. The tin can should then be placed on a hollow platform made of bricks, as you see in the picture.

Now when water is poured into the tin can, it will flow from the can into the rubber tube. But the water does not flow away. It is trapped in the tube. Do you see that the tube is somewhat like an artesian water supply? The tube takes in water at its upper end like the porous rock layer. The water is trapped in the tube as it is in the rock.

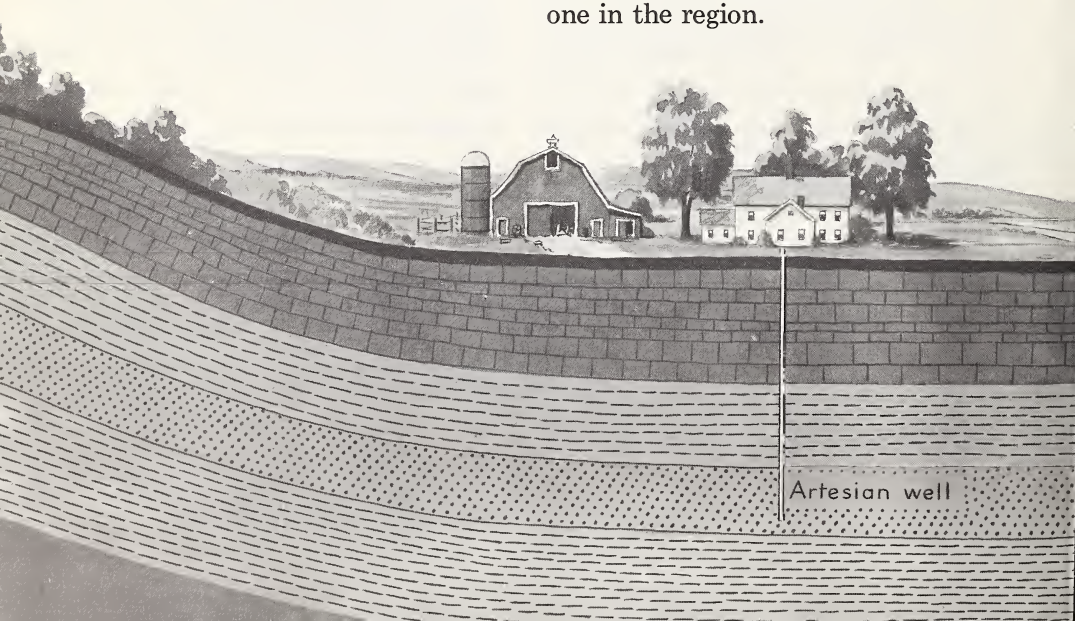
All that remains for you to do is to sink a well into the "porous rock layer." First, fill the tin can with

water. You can sink your well by making a hole in the tube with a sharp, large-sized carpet tack. Notice that once the hole is made, the water spurts into the air. How high does your water column rise?

An artesian system is like a huge underground reservoir. The arrangement of the three layers of rock makes it possible to have a continuous supply of water. The water enters an artesian system through the exposed porous layer. But care must be taken in how the water is withdrawn. We must balance what we take out by what has gone into the reservoir.

Such rock structures may be found in many regions of North America. Of course the porous layers are at different depths throughout these regions. And they include different kinds of porous rock. For instance, a rock called Dakota sandstone forms the porous layer beneath one large area of North America. Water enters this porous sandstone near the base of the Black Hills in South Dakota and along the eastern foothills of the Rocky Mountains. It moves far below the surface of the soil through parts of Nebraska, South Dakota, Colorado, and Kansas.

In many areas of North America the amount of water drawn from the underground reservoirs has been greater than the amount entering. Water no longer comes to the surface under its own pressure in these areas. This is a great loss to everyone in the region.



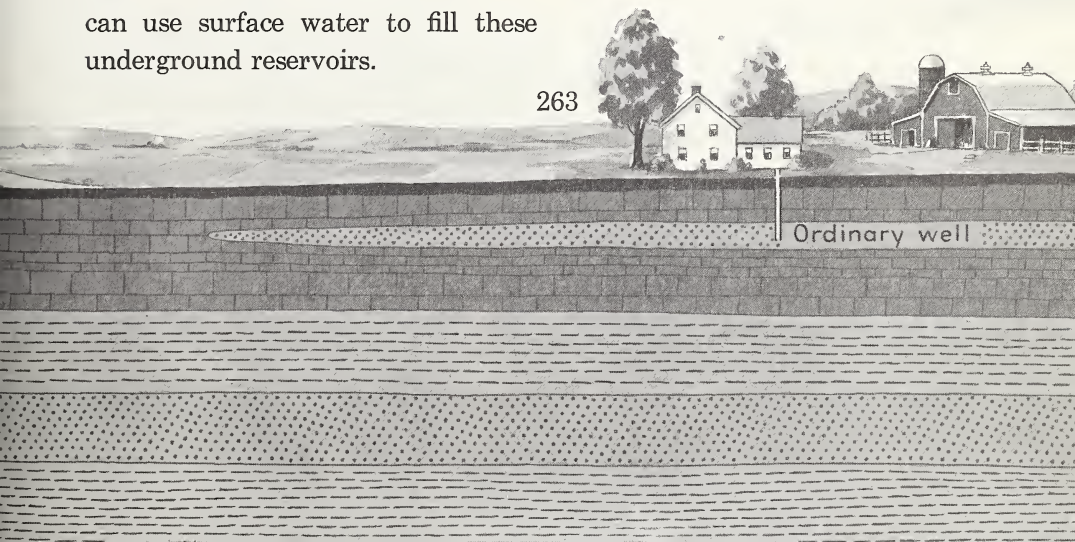
Many states and provinces are trying to protect and redevelop their artesian water supplies. There are laws to prevent waste of the water from artesian wells. Engineers from conservation departments work with owners of artesian wells to get the best possible use of water and pressure. Valves are used to help control the flow of water. All unused wells and those which leak are carefully sealed. This helps to eliminate waste. It also does much to increase the water level and pressure in the other artesian wells in the region.

Our underground reservoirs may become one of our most important sources of water. The rock layers are there! You might say that the reservoirs are built. All we have to do is to keep them filled with water. Rainfall and snowfall will help. But there is also the possibility that we can use surface water to fill these underground reservoirs.

One thing is certain: water and water sources are important to our growing country. How shall we make the best use of the rock structures that make artesian water supplies possible?

Safe Water in the Country

Perhaps you live in a small village or on a farm. The water you use may come from an artesian well. Or it may come from an "ordinary" well that has been dug in your yard. In that case the water that you drink is ground water. If you have an artesian well, your water may come from rain or snow which fell on the earth many hundreds of miles away. An ordinary well, however, is more dependent on the amount of rainfall



nearby. It must draw its supply from the water that has soaked down into the ground from the surface of the surrounding soil.

In some places an ordinary well may be dug 125 feet deep before water is reached. In other places the well may have to be dug much deeper. The level of ground water is not the same in all parts of the earth. The sides of the well are lined with brick and concrete or material that is called casing. The top of the well should have a metal covering over it. This will help to keep well water safe for drinking.

People who use water from their own wells should have the water tested from time to time. This can be done by asking someone from the Board of Health to come and test the water. It is also possible to send a sample of well water to the Board of Health for testing. Perhaps you have hiked or camped near a spring or stream. You may have noticed a sign posted nearby telling whether the water was safe to drink. Such a sign was probably posted by the Board of Health.

Sometimes water from a barnyard or an outdoor toilet or cesspool may seep through the ground. Harmful bacteria may get into the ground water. Then the well water which is drawn from this polluted ground water will also be polluted. To prevent this, it is wise to locate ordinary wells on high ground. Do you think that this is true of artesian wells also?

Making Water Pure

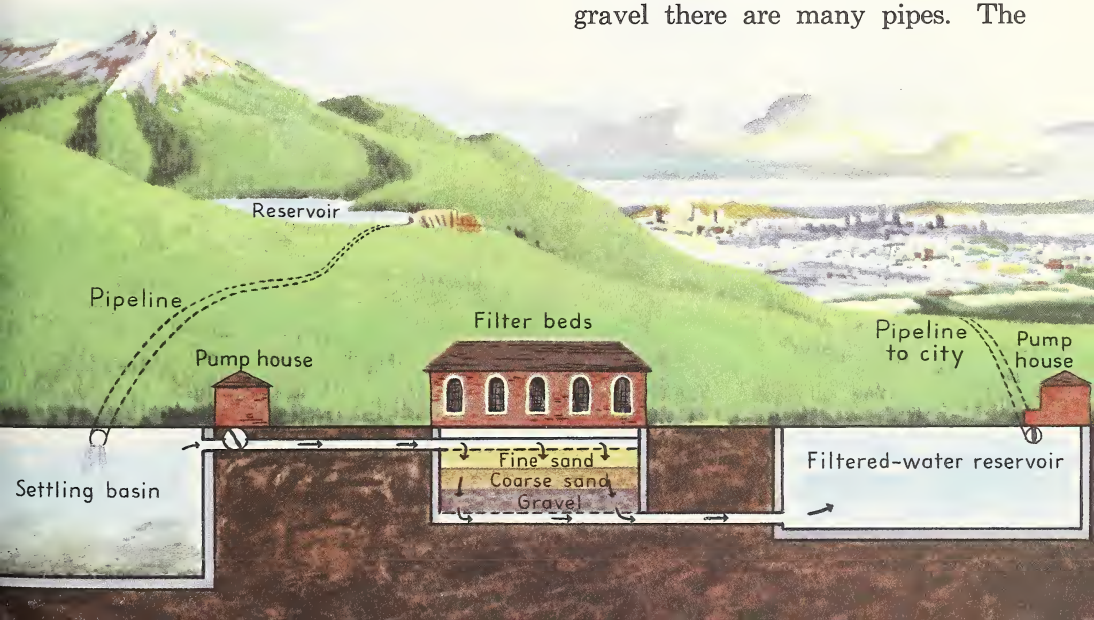
No matter where it comes from, you enjoy drinking water that is clear, colorless, and has a good taste. You also want to know that it is free from bacteria and other materials that may cause disease. These materials found in water are called impurities. To make water safe and pleasant to drink, impurities must be removed.

Look at the picture below. It shows the way one city purifies the water it uses. Rain and water from melting snow run off the watershed areas into a large reservoir. Then the water flows through pipes to another reservoir. This place is called the settling basin. The water stays here for several days. During this time soil or other solid particles which may be in the water will settle to the bottom.

After the water leaves the settling basin, it flows into what is called the filter bed. There is a layer of gravel at the bottom of this bed. On top of the gravel is a layer of coarse sand, and above this a layer of fine sand.

When the water enters the filter bed, it begins to move down through the three layers. First, it moves slowly through the fine sand. The sand catches many particles of soil and tiny plant and animal life. We usually say that the water is filtering through the sand.

Then the water flows down through the coarse layer of sand, and finally through the gravel. In the layer of gravel there are many pipes. The



pipes are made of porous material, which allows water to go through it. The material is much like that used in flower pots.

You might try an experiment to see how water can pass through porous material. First, use a can opener to cut a round hole in the bottom of a tin can. Then force a small flower pot down into the opening so that it is held in the hole, just as you see in the picture. Seal the edge between flower pot and tin can with clay or plasticine to make it watertight. Now pour just enough water into the can so that the flower pot is surrounded by water. In a short time water will begin to seep into the flower pot through its walls.

The pipes set in gravel in a filter bed work in much the same way. Water seeps from the gravel through the porous pipes. From these pipes the water flows into larger pipes. Finally, the water is carried to the homes and buildings in the city.

To make sure that drinking water is safe, a chemical called chlorine is usually added to the water after it is filtered. In very small amounts it is not harmful to the human body. But the chlorine does kill harmful bacteria.

Of course, not all cities and towns purify their water by filtering it. But most communities add chlorine or some other chemical to water to make it safe for drinking. If you live in a city or town, find out how your community purifies the water you drink.

Where Do the Drain Pipes Lead?

"Going swimming in the bay?" That is the question your father could have answered with a "yes" if he lived in a certain east coast city when he was a boy. But the boys and girls who grew up there during the 1940's and 1950's have never been allowed to go swimming in the bay. The water surrounding the city is not safe!

During the early 1900's this city was a resort area. People came from miles around to swim in the surrounding waters. Then many industries moved to the city because there were good port and shipping facilities. The population increased and the city changed from a resort to an industrial center.

The wastes from industries and from private homes were carried by pipes to the water of the bay. Gradually over the years the water became polluted. There was so much waste material in the bay that at times it colored the water. Much of the animal and plant life of the bay was destroyed. The water was no longer a safe place in which to swim.

The people in the city did something about this condition. If the water was to become clean and productive again, the waste would have to be disposed of in some other way. In 1953 this city began building a large sewage-disposal plant. In time, if all goes well, the water may be safe enough to swim in again.

In Large Communities

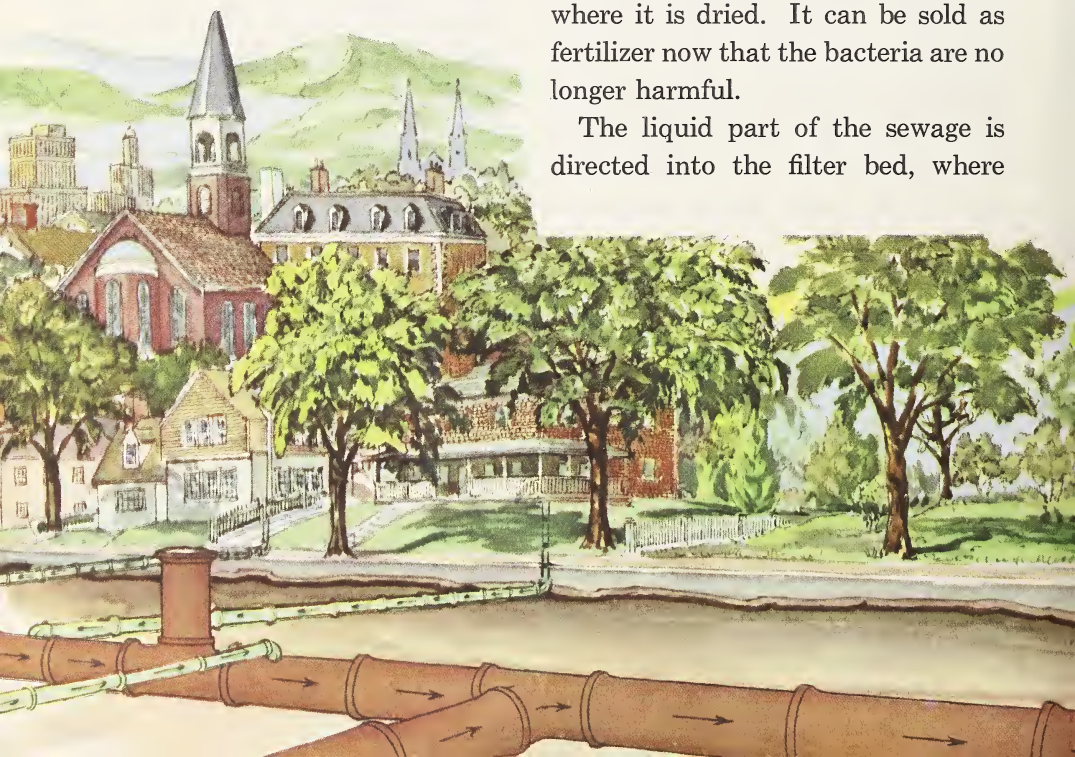
Sewage flows into rivers, lakes, and coastal waters from other cities and towns, also. When this happens, of course the water becomes polluted. It is not a pleasant thought, is it?

Some communities are correcting these mistakes. The picture below shows you how sewage is disposed of in one city. All the drain pipes in the city lead to a sewage-disposal plant where the sewage is treated to make it harmless.

At the disposal plant the sewage first flows into a big round, concrete basin. A large rake moves around and around in the basin. This helps to expose the sewage to sunlight. The energy from the sun kills some of the disease germs that are present. The sewage is pumped from this outdoor basin to a building called a separator. This building looks somewhat like a greenhouse because it is made almost entirely of glass.

The separator contains a settling basin and a filter bed. Chemicals are added to the sewage in the settling basin. The chemicals kill the harmful bacteria. Part of the sewage falls to the bottom of the settling basin. Here it is drawn off through pipes and pumped to another building where it is dried. It can be sold as fertilizer now that the bacteria are no longer harmful.

The liquid part of the sewage is directed into the filter bed, where



it flows through layers of gravel and sand. From here it is piped into a large, rectangular, outdoor basin. The liquid remains in this basin for several days. This again helps to reduce the harmful bacteria. The liquid is then tested. If after that treatment it is found to be safe, it can be piped into a bay, lake, or river that may be near the town.

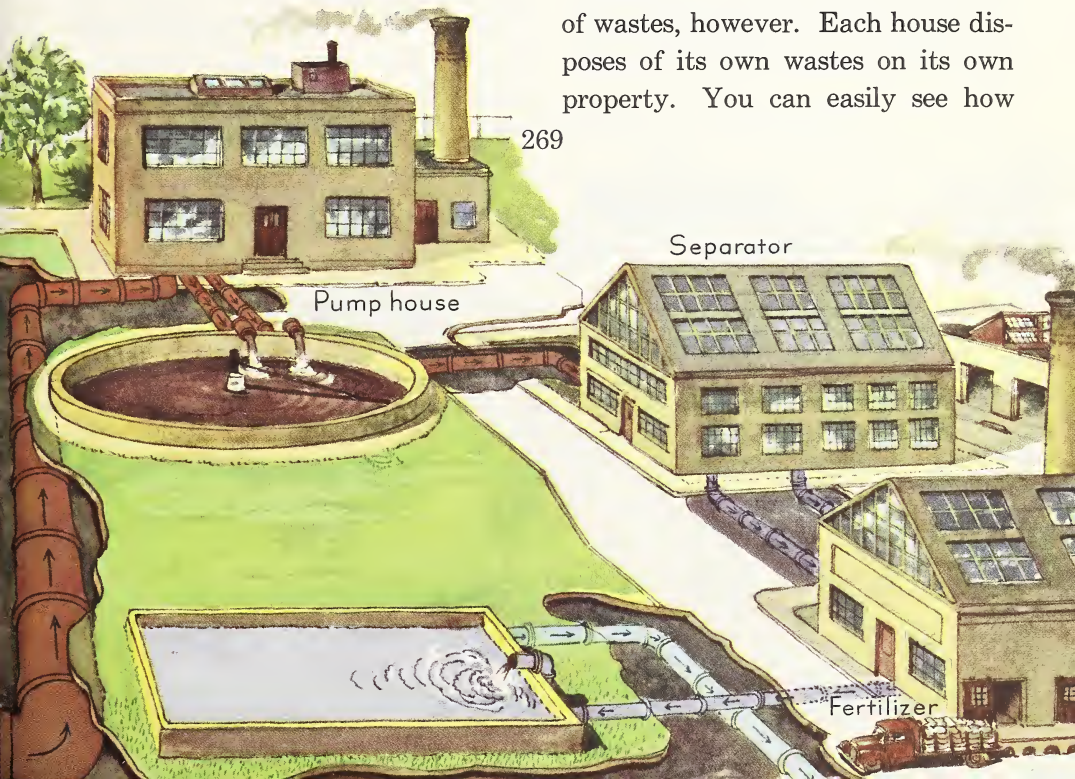
When sewage has been purified in this way, it does not pollute the water into which it flows. The beaches may be used for swimming, and animals and plant life can continue to grow in the water.

This is just one way that waste materials are disposed of without polluting water and endangering the health of people. Each city and town has its own way of disposing of sewage. How is sewage disposed of where you live?

In Small Communities

Many houses are not connected with sewers. But you would never realize it by looking at their sinks and toilets. The water and wastes are piped out of the houses just as though they were being carried to a sewer.

There is no community collection of wastes, however. Each house disposes of its own wastes on its own property. You can easily see how



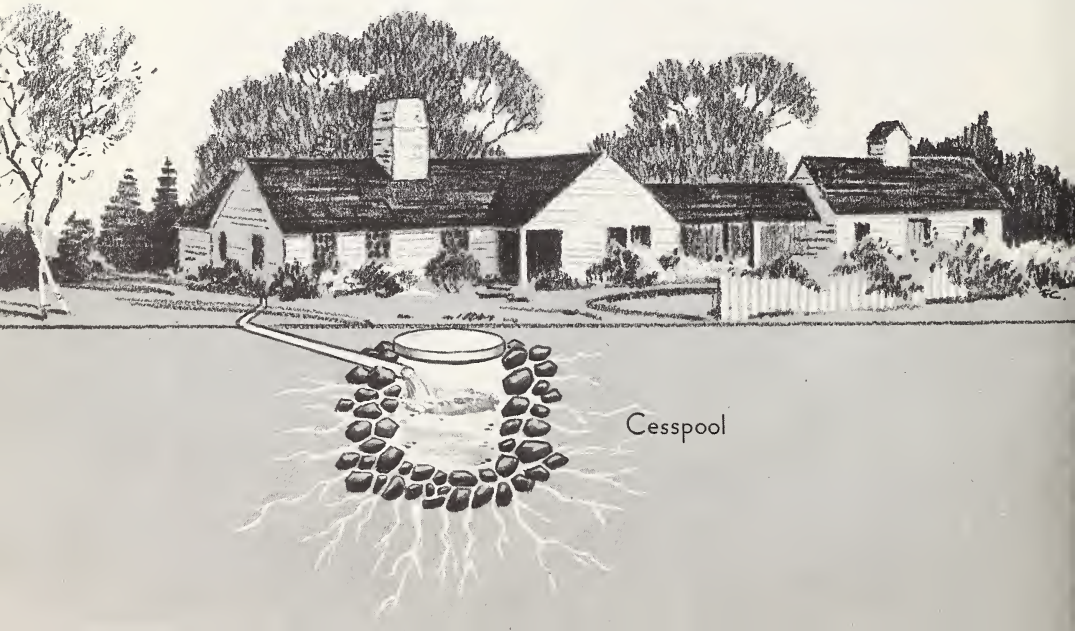
this may become a very real health problem. Each home must dispose of its wastes in such a way that they will not be harmful and cause disease.

There are two kinds of private sewage-disposal systems that are usually used: the cesspool and the septic tank. Of the two the septic tank is the safer.

A cesspool consists of a large hole in the ground. The hole is lined with rocks or concrete blocks, which are not cemented together. The top of the cesspool is covered with a tightly fitting, concrete lid. This helps to keep out insects and other animals.

The wastes from the house are carried to the cesspool through pipes. The liquids pass into the soil through the openings between the rocks or blocks. Gradually the soil around the cesspool will become polluted. Wells or nearby water supplies may be infected. Cesspools are of little use in ground that is low and wet. The soil cannot absorb the liquid from a cesspool if the soil already holds all the water that it can.

A septic tank works in an entirely different way from a cesspool. Waste materials flow into a watertight tank. The waste remains in the septic tank for 24 hours or more. During this time bacteria change much of the solid part of the waste to harmless liquid. When the height of the liquid reaches the outlet pipes, there is a flow of liquid from the tank into the soil. The area around the tank is



Cesspool

called the leaching field. Here tiles are placed just below the surface of the soil. The tiles allow air to get to the liquid. The liquid evaporates before it can go very far.

Not all the solid part of the waste is changed to liquid. Some of it remains in the tank and settles to the bottom as sludge. In time there will be an accumulation of sludge in the tank. The sludge will have to be pumped from the tank in order to keep the tank operating properly.

Disposing of Other Waste Materials

Getting rid of the wastes from our kitchens is a very serious problem also. Much of the wastes are the remains of animals and vegetables which are used for food. Then, too, there are the containers in which food was packed. These include tin cans, bottles, and paper.

The animal and vegetable remains are not a health menace when fresh. But when these remains stand for any length of time, they begin to decay. This refuse must be safely disposed of to keep the community healthy.

Sanitary Landfill Method

In some communities garbage and rubbish are taken to an open dump. These dumps attract rats, and mice, and many insects. Sometimes the waste materials in an open dump are burned. The smoke and odors are unpleasant and even harmful. In

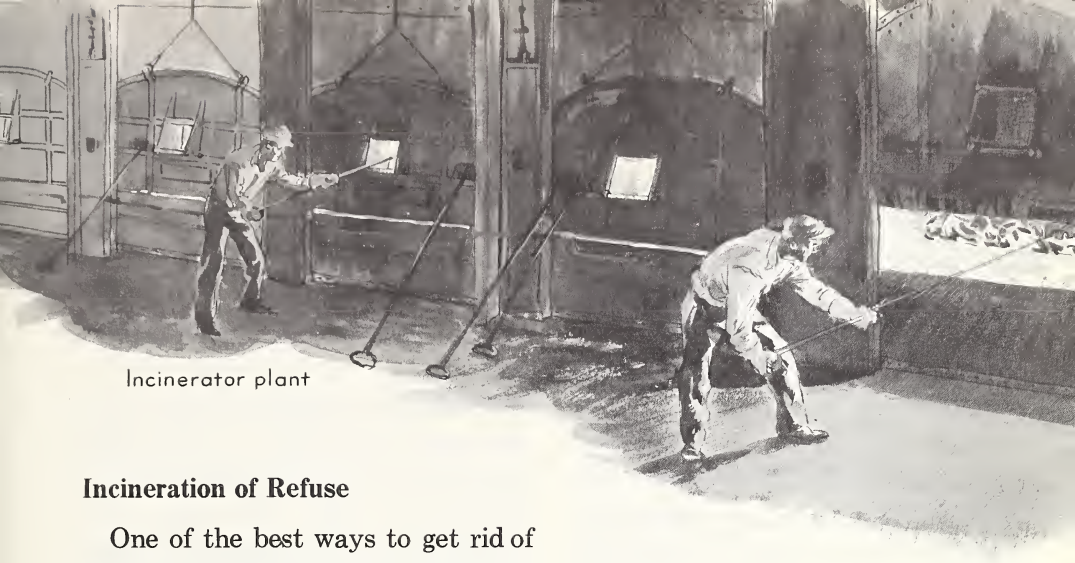
other places refuse is dumped into a river or lake, polluting the water.

Sometimes the garbage collected in cities and towns is fed to hogs. It has been found that many hogs fed untreated garbage have contracted a disease called trichinosis. This may spread to people who eat meat from these animals. In some parts of the country no garbage may be fed to hogs until after it has been heated at 212° F for 30 minutes. This destroys disease germs.

One good way to dispose of waste materials is called sanitary landfill. First, a broad, deep trench is dug by a tractor. The day's collection of refuse is dumped into part of the trench. The tractor crushes the waste materials under its steel tracks. Then soil is pressed over the refuse to make a compact covering.

When the trench is filled, other trenches are dug. Later, when all the trenches are completely filled and covered with soil, grass is planted. In some communities gravel pits, quarries, marshy places, or gullies are filled with refuse and topped with soil and grass in this way. After some time the "dump" may become a park or a playground.

In some homes garbage-disposal units have been installed in the kitchen sink. These machines grind garbage extremely fine. It is then washed down the drain and carried away with the sewage. However, in some communities widespread use of this method of garbage disposal is not yet advisable. Too much water might be wasted or the community's system of sewage disposal might be overloaded.



Incinerator plant

Incineration of Refuse

One of the best ways to get rid of community garbage and rubbish is to burn it in a specially designed furnace. The temperature in many of these garbage furnaces is about 2000° F. It is necessary to have it so hot to burn the garbage completely.

In many incinerator plants all the waste materials are not burned. Some are salvaged or separated from the rest. For example, grease and fats may be recovered from garbage by the use of steam. After the melted fat is salvaged, it is shipped to manufacturers who have use for it. Fertilizing material may also be recovered from garbage. This can be an important way of supplying fertilizers for the soils of the world.

Another important type of conservation is the salvaging of paper and rags. These may be sorted out and reused in the manufacture of paper and other products. Tin cans, other metals, and glass may also be reused in the manufacture of many things that we need. When these materials are destroyed, they are lost to us.

By using his intelligence, man has found sanitary, safe ways of disposing of garbage and other refuse. He has also found that as he removes a health menace from his community, he can recover important materials from the wastes. These salvaged materials can point the way to a richer life for all. Rather than the continued destruction of our goods and resources we can look for ways of getting fuller use of them.

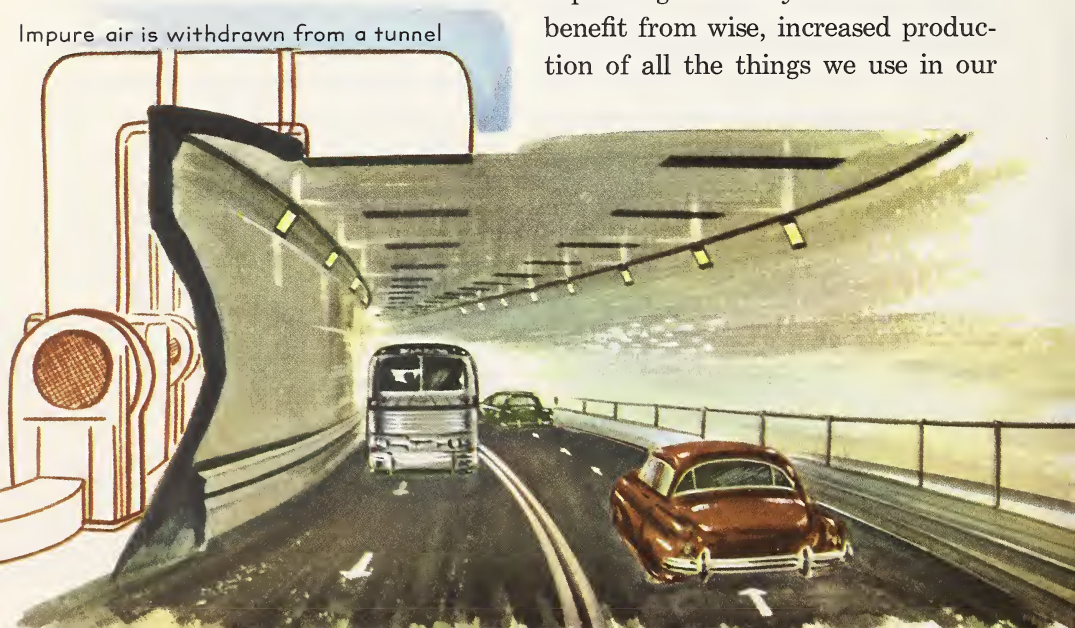
The Air You Breathe

You are probably very careful about the food and water that you take into your body each day. But what about the air you breathe? If you live in the country, it may never have occurred to you that impurities in the air may be a very serious community problem.

Many different gases, chemical compounds, and just plain dust and dirt may be in the smoke that pours out of chimneys. The mere burning of coal will throw into the air such things as soot, ash, harmful gases, and even small amounts of acids and other chemicals. The burning of natural gas or fuel oil also releases acids and other impurities. Even the drying of paints and varnishes adds fumes to the air.

If you have been in heavy automobile traffic for any length of time, you know how difficult it may become to breathe when the air is filled with fumes. Automobiles, trucks, and busses use gasoline and oil. As these fuels are used, the fumes from the exhaust pipes mix with the air we breathe.

Many other impurities are added to the air each day from some of our huge industrial plants. Impurities mix with the air as chemicals are manufactured, petroleum is refined, or as metals are worked. We are living more and more in a world of expanding industry. We will all benefit from wise, increased production of all the things we use in our



Impure air is withdrawn from a tunnel

Sampling air in an industrial area

daily living. But we should also realize that at the same time we may be polluting the air we breathe with acids and other impurities. These impurities can prove to be very harmful to the health of us all.

How do impurities in the air affect people who breathe them day in and day out during the year? This is probably one of the greatest unsolved problems we have today.

It may not take a great deal of impurity in the air to bring about ill effects. It has been estimated that we each breathe as much as 2700 gallons of air into our lungs each day. Even though there is only a small amount of impurity in each gallon that we breathe, we may take into our lungs about 2700 times that amount during the course of one day.

Impurities in the air can affect plants and animals also. Very small amounts of sulfur dioxide in the air can cause great damage to the leaves of plants such as spinach and lettuce. Other gases also can injure plants. Animals may be affected when they breathe impure air or when they feed on plants which have been damaged by gases or harmful chemicals.

Much work is being done to decrease the amount of impurities in the air. Groups from many different communities are cooperating with each other. This is important because impurities are often carried from one community to another as the air moves about.

You might find out what impurities are likely to be in the air you breathe. How do the impurities enter the air that is around you? The local Board of Health probably could give you much valuable information on this problem.

A More Healthful World

The world in which we live is becoming a more healthful place. Most people work hard at trying to keep their homes and communities clean. This is one way to prevent the spread of disease. People in health departments help in protecting communities. But it is more important that all the people in each community should become concerned about living in clean, pleasant places.

Garbage disposal, sewage disposal, and our water supply are really all part of the same problem. We cannot afford to be careless about any one of these. More and more we are realizing that each is an important link in keeping the whole community healthy.

Much has been learned about the air around us and how it affects our community health. But only a beginning has been made. There is much to find out and to do.

Probably one of the most important things man has learned is that he can change his community. He can change it for better or worse. This we know—the changes should always be the kind that benefits man. Proper planning and care can create a pleasant, clean, and healthful world in which to live. You will have a part in building this world!

LEARNING MORE

1. Find out how your community gets its water supply. Make a series of pictures showing the steps in making your water safe for drinking.

2. What diseases are spread by water? How are they caused? Report your findings to the class.

3. Make a map of your community showing where there are breeding places of insects and other animals. Put dots on the map showing where there are stagnant pools of water, marshy places, rubbish piles, open garbage cans, manure piles. After you have spotted them, find out from the Board of Health how you might help in getting rid of these breeding places.

4. In 1948 the World Health Organization was formed. It is a special agency of the United Nations. Look in an encyclopedia to find out what this organization does to make the world a more healthful place.

Science Words

This part of your book is a science dictionary. It will help you find the meanings of words which are used in your book. The page number following each word shows you on what page the word is first found.

The following list of letter sounds will help you to use correctly the markings of your science words.

ă *as in* căt	ĕ *as in* hĕr	ô *as in* hôrse	oi *as in* soil
ā *as in* māde	ê *as in* bêgin	ȯ *as in* ȯbey	o͝o *as in* to͝ok
à *as in* gràss		o͝ *as in* sō͝ft	o͞o *as in* mo͞on
â *as in* câre	ĭ *as in* gĭft		ou *as in* out
ä *as in* bärn	ī *as in* rīde	ŭ *as in* cŭp	u͟ *as in* ed u͟cate
		ū *as in* mūsic	ng *as in* sing
ĕ *as in* nĕt	ŏ *as in* tŏp	û *as in* bûrn	th *as in* thin
ē *as in* hē	ō *as in* jōke	ů *as in* ůnite	t͟h *as in* t͟hat

am mo'ni'um chlo'ride (ă mō'nĭ ŭm klō'rīd). A chemical compound made up of nitrogen, hydrogen, and chlorine. It is used in dry cells (p. 10).

An drom'e da (ăn drŏm'ē dà). A constellation seen in the fall and early winter. The hazy spot of light near one of its stars is the Andromeda galaxy, a system of billions of stars, a million light-years away (p. 112).

an'nu al (ăn'ū ăl). Any plant which lives only one year or season (p. 74).

Ant arc'tic Cir'cle (ănt ärk'tĭk sûr'k'l). An imaginary line circling the southern part of the earth. It marks the boundary of the south polar region (p. 42).

an'thra cite (ăn'thrà sīt). Hard coal. It burns slower than soft coal and with little smoke or flame (p. 19).

Arc'tic Cir'cle (ärk'tĭk sûr'k'l). An imaginary line circling the northern part of the earth. It marks the boundary of the north polar region (p. 41).

ar'ter y (är'tĕr ĭ). The name given to the tubes which carry the blood from the heart to all parts of the body (p. 6).

at'mos phere (ăt'mŏs fēr). The layer of gases which surrounds the land and water parts of the earth. It can be thought of as an ocean of air thousands of miles deep (p. 24).

at'om (ăt'ŭm). The smallest part into which a basic substance such as iron can be divided and still be iron. An atom consists of particles called electrons, protons, and neutrons. All substances are made up of atoms (p. 9).

a tom'ic en'er gy (ă tŏm'ĭk ĕn'ĕr jĭ). The energy which is released when atoms are broken up (p. 9).

au ro'ra bo're a'lis (ô rō'rà bō'rē ā'lĭs). Streams of light originating in the upper atmosphere of the Northern Hemisphere. They are also called northern lights (p. 209).

au'tumn (ô'tŭm). The season which follows summer. It is also called fall. In the Southern Hemisphere autumn begins about March 21 and ends about June 22 (p. 29).

ax'is (ăk'sĭs). The imaginary straight line through the center of the earth from one geographic pole to the other. The earth rotates about its axis (p. 42).

ax'le (ăk's'l). The bar or rod on which a wheel turns. Sometimes the rod rotates along with the wheel (p. 223).

bar mag'net (bär măg'nĕt). A bar of iron or steel which has the power to attract iron, steel, cobalt, and nickel (p. 190).

bas'ic ma chines' (bās'ĭk mà shēnz'). The inclined plane, lever, wheel and axle, wedge, screw, and pulley are the six basic machines. All other machines are combinations of two or more of these six (p. 222).

bi en'ni al (bī ĕn'ĭ ăl). A plant which lives for two years. It produces roots and leaves the first year and flowers, fruit, and seed the second year (p. 74).

Big Dip'per (bĭg dĭp'ẽr). A group of seven stars which one can imagine form the outline of a dipper (p. 105).

bi tu'mi nous coal (bĭ tū'mĭ nŭs kōl). A type of soft coal (p. 18).

black'smith' (blăk'smĭth'). A person who hammers iron into various shapes after heating it in a fire (p. 16).

blue'stem' grass (bl$\overline{oo}$'stĕm' gras). A type of grass which is highly valued for pastures. It has bluish-grey stems (p. 151).

broad'-leaved' for'ests (brôd'lēvd' fŏr'ĕsts). A growth of trees such as oaks, maples, or other trees with wide leaves (p. 151).

cal'ci um (kăl'sĭ ŭm). One of the basic substances. Calcium is one of the elements which make up the chemical called lime (p. 57).

car'bon (kär'bŏn). An element. Coal consists mostly of carbon (p. 10).

car'bon di ox'ide (kär'bŏn dī ŏk'sīd). A colorless gas made of the elements carbon and oxygen. Animals exhale carbon dioxide (p. 7).

car'i bou (kăr'ĭ b$\overline{oo}$). A North American reindeer (p. 146).

cess'pool' (sĕs'p$\overline{oo}$l'). A deep, covered pit specially prepared to receive sewage (p. 264).

check dam (chĕk dăm). A small dam made of boards or wire. It helps to hold back the movement of water and soil down a gully (p. 169).

chem'i cal (kĕm'ĭ kăl). All things are made of chemicals. Such things as water and salt are called chemical compounds (p. 6).

chem'i cal en'er gy (kĕm'ĭ kăl ĕn'ẽr jĭ). The energy released when chemicals act on each other. Chemical energy sometimes produces heat, light, or electricity (p. 6).

chlo'rine (klō'rēn). An element which is yellowish-green in its gaseous form. Chlorine is used to help purify water (p. 266).

chlo'ro phyll (klō'rō fĭl). A chemical compound. It is the chemical which gives the green color to plants (p. 57).

cir'cuit (sûr'kĭt). A path for electricity (p. 11).

clock'wise' ro ta'tion (klŏk'wīz' rō tā'shŭn). Rotation in the same direction as that in which the hands of a clock move (p. 202).

cold'-blood'ed an'i mals (kōld'blŭd'ĕd ăn'ĭ măl z). Animals whose blood stays about the same temperature as their surroundings. Fish and snakes are cold blooded (p. 80).

com mu'ni ty (kŏ mū'nĭ tĭ). All the plants and animals living in one place (p. 145).

com'pass (kŭm'pas). A magnetic instrument used to tell directions (p. 189).

com plex' ma chine' (kŏm plĕks' mà shēn'). A combination of several basic machines (p. 232).

con'den sa'tion (kŏn'dĕn sā'shŭn). When water vapor in the air changes into rain, the change is called condensation (p. 24).

con'stel la'tion (kŏn'stĕ lā'shŭn). Any stars in the sky which seem to form a group. Ancient peoples imagined that these groups of stars formed the outlines of various objects, animals, and heroes (p. 105).

con'tour-plow (kŏn't$\overline{oo}$r plou). To plow the soil so as to take advantage of the curve of the ground (p. 178).

coun'ter clock'wise' ro ta'tion (koun'tẽr klŏk'-wīz' rō tā'shŭn). Rotation in the opposite direction from that in which the hands of a clock move (p. 202).

cur'rent of e lec'tric'i ty (kûr'ĕnt ŏv ē lĕk'-trĭs'ĭ tĭ). Electricity moving steadily from one place to another. It usually flows through a conductor such as iron or copper wire (p. 10).

de cid'u ous trees (dē sĭd'ū ŭs trēz). Trees which drop their leaves in the fall (p. 58).

di am'e ter (dī ăm'ē tẽr). The distance straight through the center of a round object, such as a circle or a planet (p. 191).

dir'i gi ble (dĭr'ĭ jĭ b'l). A huge balloon driven by motors. Helium and other gases make this aircraft lighter than air (p. 235).

drag (drăg). The force which holds back the forward movement of an airplane (p. 243).

e lec'tric'i ty (ē lĕk'trĭs'ĭ tĭ). A form of energy which results from the movement of electrons (p. 9).

e lec'trons (ē lĕk'trŏnz). The outer parts of atoms. These tiny particles have negative charges of electricity (p. 11).

el'e ment (ĕl'ē mĕnt). A basic substance made up of only one kind of atom. For example, the element oxygen is made up of nothing but oxygen atoms. There are about 100 basic substances (p. 56).

en'er gy (ĕn'ĕr jĭ). The power or ability to do something. Heat, light, and electricity are some forms of energy (p. 4).

e qua'tor (ē kwā'tĕr). An imaginary line around the center of the earth, equally distant from the north and south poles (p. 29).

e rode' (ē rōd'). To wear away. Soil is often eroded by water and wind (p. 178).

e vap'o rate (ē văp'ō rāt). To change from a liquid to a gas. When liquid water changes into gaseous water, or water vapor, we say that the water evaporates (p. 24).

ev'er green' (ĕv'ĕr grēn'). Any plant which remains green throughout the year (p. 60).

fil'ter bed (fĭl'tĕr bĕd). A layer of sand or gravel which strains out solid particles from water or other liquids (p. 265).

fric'tion (frĭk'shŭn). Resistance which comes from two surfaces rubbing on each other (p. 218).

frost line (frôst līn). The depth below ground at which water will not freeze (p. 93).

fu'el (fū'ĕl). Any material that can be used to supply heat or other forms of energy (p. 8).

ful'crum (fŭl'krŭm). The support on which a lever turns (p. 220).

fun'gus (fŭng'gŭs). A non-green plant. Bacteria, molds, and mushrooms are all fungi (p. 63).

gal'ax y (găl'ăk sĭ). A system of millions of stars. The Milky Way is the name of the galaxy to which our sun belongs (p. 99).

gas'o line (găs'ō lēn). A light, inflammable fuel obtained from petroleum oil. It is used in automobile and airplane engines (p. 21).

ge'o graph'i cal poles (jē'ō grăf'ĭ kăl pōlz). The northern and southern ends of the earth's axis (p. 196).

grass'land' (gras'lănd'). A region of rather level land covered by grass (p. 145).

grav'i ty (grăv'ĭ tĭ). The force which pulls everything toward the center of the earth (p. 5).

ground wa'ter (ground wô'tĕr). The water stored in the soil and in layers of rock below the surface of the ground (p. 259).

heat (hēt). A form of energy which results when fuels burn, or combine rapidly with oxygen (p. 7).

hel'i cop'ter (hĕl'ĭ kŏp'tĕr). A flying machine which is driven forward by propellers revolving horizontally (p. 235).

hel'i port (hĕl'ĭ pōrt). A prepared space on which a helicopter can land (p. 248).

he'li um (hē'lĭ ŭm). A noninflammable gaseous element found on the earth and sun (p. 11).

hi'ber na'tion (hī'bĕr nā'shŭn). A state of inactivity in a protected place during cold weather (p. 92).

horned lark (hôrnd lärk). A bird often found in grassland communities (p. 162).

hy'dro gen (hī'drō jĕn). A colorless, inflammable gaseous element. When it burns in air, it combines with oxygen to form the chemical compound water (p. 9).

hy'dro pon'ics (hī'drō pŏn'ĭks). A way of growing plants without soil. Water and the necessary chemicals are supplied to plants by artificial means (p. 58).

in clined' plane (ĭn klīnd' plān). A slanting surface. A road up a hill is an inclined plane since it is a slanted surface with one end higher than the other (p. 215).

in'su lat'ed (ĭn'sŭ lāt'ĕd). Covered with a material such as rubber or cotton. The covering on insulated wire helps prevent heat or electricity from escaping (p. 127).

i'ron (ī'ẽrn). A metallic element which can be magnetized. Plants, animals, and men need iron in their food to grow (p. 5).

jet plane (jĕt plān). An airplane which is thrust through the air by a stream of hot gases escaping from its engine (p. 134).

ker'o sene' (kĕr'ō sēn'). A thin, colorless oil made from petroleum. It can be used as a fuel for many different purposes (p. 21).

leaf scar (lēf skär). The layer of tissue which grows over the spot where a leaf has been attached to a branch (p. 59).
le'ver (lē'vẽr). A bar which is used to move a heavy object. The lever is one of the six basic machines (p. 219).
li'chen (lī'kĕn). A plant usually found growing on rocks or tree trunks. It is flowerless and leafless (p. 73).
lift (lĭft). Air moving over the wings of an airplane provides its lift (p. 239).
light (līt). A form of energy. Electricity produces light energy (p. 6).
light'-year' (līt'yēr'). The distance light travels in one year (p. 103).
lime'stone' (līm'stōn'). A rock made mostly from the shells of sea animals which lived thousands of years ago. It can be cut into blocks and used for buildings (p. 19).
lode'stone' (lōd'stōn'). An iron compound found in the ground. It is a natural magnet and can attract iron or steel (p. 190).

ma chine' (mà shēn'). A device which can be used to direct energy to do work. A knife, a ladder, and a shovel are examples of machines which make man's work easier (p. 9).
mag ne'si um (măg nē'shĭ ŭm). A silver-white, metallic element. Magnesium is a very light metal (p. 57).
mag net'ic field (măg nĕt'ĭk fēld). The area around a magnet in which the magnet has the power of affecting or attracting iron objects (p. 206).
mag net'ic poles (măg nĕt'ĭk pōlz). The ends of a magnet. The earth has magnetic poles (p. 194).
mag'net ism (măg'nĕ tĭz'm). The power of a substance to attract iron or steel (p. 189).
man'ga nese di ox'ide (măng'gà nēs dī ŏk'sīd). A black chemical compound made of the elements manganese and oxygen. It is used in dry cells (p. 10).
me chan'i cal en'er gy (mẽ kăn'ĭ kăl ĕn'ẽr jĭ). The energy of moving objects (p. 9).
met'al (mĕt''l). Any of several elements, such as iron or copper, which conduct electricity and glow when heated to high temperatures (p. 127).
mi'cro scope (mī'krō skōp). A scientific instrument which enlarges the size of objects seen through it (p. 126).
mi'grate (mī'grāt). To travel at regular intervals from one place to another (p. 86).
Milk'y Way (mĭl'kĭ wā). A broad band of pale-white light which stretches across the sky at night (p. 98).
Milk'y Way sys'tem (mĭl'kĭ wā sĭs'tĕm). All the stars which belong to our Galaxy. Our sun is one of these stars (p. 108).
min'er al (mĭn'ẽr ăl). A substance occurring in nature. It may be either an element or a compound. Coal, gold, salt, and copper ore are a few minerals (p. 26).
mol'e cule (mŏl'ẽ kūl). All molecules are composed of atoms. A molecule of water is made of two atoms of hydrogen and one atom of oxygen. A drop of water consists of millions of molecules of water (p. 197).

ni'tro gen (nī'trō jĕn). An element in the air in the form of a gas which is colorless, odorless, and tasteless. Nitrogen is also found in the soil as a part of nitrates. A nitrate is a chemical that contains nitrogen and oxygen (p. 57).
non'-green' plants (nŏn'grēn' plănts). Plants which do not contain chlorophyll and are unable to make their own food (p. 63).
North Star (nôrth stär). The star toward which the northern end of the earth's axis seems to point. It is often called the pole-star (p. 43).
North'ern Hem'i sphere (nôr'~~th~~ẽrn hĕm'ĭ-sfēr). That half of the earth which is north of the equator (p. 29).

oil shale (oil shāl). Shale rock which has become soaked with petroleum (p. 21).

O ri'on (ō rī'ŏn). A large constellation with three bright stars in a line. Early peoples imagined that these formed the belt of the hunter Orion (p. 105).

ox'y gen (ŏk'sĭ jĕn). An element found as a gas in the air we breathe. It is colorless, odorless, and tasteless, and is necessary for life. It is a part of many chemical compounds, such as water and sugar (p. 132).

peat (pēt). A dark material formed of partly decayed trees and other plant life in swamps. It may be used as a fuel (p. 18).

per en'ni al (pĕr ĕn'ĭ ăl). Any kind of plant that lives on from year to year (p. 74).

pe tro'le um (pĕ trō'lē ŭm). A dark, oily liquid obtained by drilling wells. Gasoline, kerosene, motor oil, and certain waxes are obtained from petroleum (p. 19).

phos'pho rus (fŏs'fō rŭs). An element that is yellowish and waxy when pure. It is an important part of many chemical compounds found in soil and foods (p. 57).

plan'et (plăn'ĕt). One of nine bodies in the solar system which revolve around the sun. We live on the planet called Earth (p. 40).

po'rous (pō'rŭs). Full of tiny holes. Liquids can pass through porous material. Sandstone is a porous rock (p. 260).

po tas'si um (pō tăs'ĭ ŭm). A soft, bluish-white, metallic element. Potassium compounds are found in soil and are very important to plants and animals (p. 57).

prai'rie re'gions (prâr'ĭ rē'jŭnz). Large, treeless tracts of level or gently rolling grassland. The central portion of the United States is a prairie region (p. 151).

pre cip'i ta'tion (prē sĭp'ĭ tā'shŭn). Water that falls as rain, snow, sleet, or hail (p. 152).

pro pel'ler (prō pĕl'ēr). A device for pulling a plane forward through the air. It may have two, three, or four blades (p. 240).

Prox'i ma Cen tau'ri (prŏk'sĭ mà sĕn tô'rī). The star nearest our solar system (p. 103).

pul'ley (po͝ol'ĭ). A basic machine consisting of a wheel with a grooved rim into which a rope fits (p. 226).

re flect' (rē flĕkt'). To turn back light. We see most objects by the light which they reflect (p. 142).

re volve' (rē vŏlv'). To move around in a circular or curved path. It takes the earth 365¼ days, or one year, to revolve once around the sun (p. 40).

rock'et en'gine (rŏk'ĕt ĕn'jĭn). A type of engine which carries its own oxygen supply. It does not rely upon the oxygen in the atmosphere to burn its fuel (p. 253).

root hairs (ro͝ot hârz). Little extensions on roots through which water enters. Root hairs are small, thin tubes closed at the free end (p. 55).

ro'tate (rō'tāt). To turn on an axis the way a wheel turns on its axis. The earth rotates once every 24 hours (p. 40).

rust (rŭst). Iron oxide. This reddish-brown chemical compound forms when iron combines with the oxygen in the air (p. 5).

sat'el lite (săt'ĕ līt). A smaller body that revolves around a larger one (p. 254).

screw (skro͞o). One of the six basic machines. A screw is a slender, round bar having a spiral strip of metal, or thread (p. 226).

sea lev'el (sē lĕv'ĕl). The height of land is usually measured from sea level. Sea level is set at halfway between the height of high and low tide (p. 17).

sep'a ra'tion lay'er (sĕp'à rā'shŭn lā'ĕr). A thin layer which grows between the stalk of a leaf and the branch on which the leaf is growing (p. 59).

sep'tic tank (sĕp'tĭk tăngk). An underground tank in which sewage is held until it becomes harmless (p. 270).

set'tling ba'sin (sĕt'lĭng bā's'n). A reservoir where water or other liquid is kept for a while to allow soil or solid particles to settle to the bottom (p. 265).

shale (shāl). Rock consisting mostly of clay which has been pressed and hardened (p. 18).

Sir'i us (sĭr'ĭ ŭs). A brilliant star often called the dog star (p. 104).

sound (sound). A form of energy which comes from vibrations (p. 7).

South'ern Hem'i sphere (sŭ~~th~~'ĕrn hĕm'ĭ-sfēr). That half of the earth south of the equator (p. 30).

spring (sprĭng). The season of the year following winter. In the Southern Hemisphere spring begins about September 23 and ends about December 22 (p. 30).

spring bal'ance (sprĭng băl'ăns). A device for measuring weight or force by means of a spiral spring (p. 217).

star (stär). A body, such as our sun, which gives off light and heat (p. 31).

steam en'gine (stēm ĕn'jĭn). An engine run by steam. Steam engines were used in early steamboats and locomotives (p. 16).

sul'fur (sŭl'fĕr). A yellow, nonmetallic element used in gunpowder and matches. It is also an important part of many foods (p. 57).

sul'fur di ox'ide (sŭl'fĕr dī ŏk'sīd). A chemical compound which forms when sulfur combines with oxygen. When mixed with water, it forms a harmful acid (p. 275).

sum'mer (sŭm'ĕr). The season of the year following spring. In the Southern Hemisphere summer begins about December 22 and ends about March 21 (p. 30).

sun (sŭn). The star about which the earth and other planets revolve. It supplies us with light and heat (p. 9).

sun'spots' (sŭn'spŏts'). Dark spots sometimes seen on the sun's surface. They are believed to be giant cyclones (p. 209)

sur'face wa'ter (sûr'fĭs wô'tĕr). The water which moves along or collects on the surface of the land (p. 259).

the'o ry (thē'ō rĭ). An opinion usually based on some observed facts. It may help to explain why something occurs (p. 11).

ther'mo stat (thûr'mō stăt). An automatic device for controlling temperature (p. 81).

thrust (thrŭst). The force which moves an airplane forward through the air (p. 241).

top'soil' (tŏp'soil'). The loose, top layer of the earth's surface (p. 19).

trib'u tar'y (trĭb'ū tĕr'ĭ). A stream or river which flows into a larger river or lake (p. 174).

tril'lion (trĭl'yŭn). One million million, or 1,000,000,000,000 (p. 103).

Trop'ic of Can'cer (trŏp'ĭk ŏv kăn'sĕr). An imaginary circle around the earth north of the equator. The sun is directly overhead at the Tropic of Cancer on June 22 (p. 41).

Trop'ic of Cap'ri corn (trŏp'ĭk ŏv kăp'rĭ-kôrn). An imaginary circle around the earth south of the equator. The sun is directly overhead at the Tropic of Capricorn on December 22 (p. 42).

tun'dra (to͝on'drə). A vast stretch of flat or gently rolling marshy land in the north arctic region (p. 162).

tung'sten (tŭng'stĕn). A metallic element used for the wires in electric-light bulbs (p. 130).

u ra'ni um (ū rā'nĭ ŭm). A hard, heavy, white, metallic element found in pitchblende. It is used to produce atomic energy (p. 26).

veins (vānz). Tubes in our bodies through which blood moves from all parts of the body back to the heart (p. 6).

warm'-blood'ed an'i mals (wôrm'blŭd'ĕd ăn'ĭ mălz). Animals which maintain a rather constant temperature even though the temperature of the places in which they live moves up and down (p. 80).

wa'ter shed' (wô'tĕr shĕd'). The sloping land from which water drains into streams, rivers, or lakes (p. 181).

wedge (wĕj). One of the six basic machines. It is usually a piece of wood or metal thick at one end and thin at the other (p. 226).

wind'lass (wĭnd'lăs). A machine for hoisting or hauling. It usually consists of a wheel and axle (p. 223).

win'ter (wĭn'tĕr). The season of the year following autumn. In the Southern Hemisphere winter begins about June 22 and ends about September 23 (p. 30).

zinc (zĭngk). The bluish-white metallic element of which the covering of a dry cell is made (p. 10).

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for Experimenting in Science

SCIENCE TODAY AND TOMORROW

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Foreword

Science Today and Tomorrow

During the last twenty-five years, science has grown steadily in the elementary schools of the United States, Canada, and various countries of Europe, Asia, and Africa. This is no ordinary event, for new areas are not easily established in the elementary school, owing to the tremendous pressure of various groups to gain the attention of children.

Science in the elementary school has to a large extent been developed by classroom teachers. They have experimented with new activities, new content, and new methods. Many of them have constructed curriculum materials and developed reading materials in science for the elementary school. As a result of this work, instruction in science in the elementary school is uniquely designed for use by classroom teachers.

The new elementary-school program with its emphasis on science is a feasible program because it recognizes that the classroom teacher has many professional tasks; teaching science is but one of them. The teacher is a specialist in the education of children and not necessarily a specialist in science. There is no need for classroom teachers to feel any responsibility for specialized science tasks, such as naming all the objects in the environment, animate or inanimate, or serving as a field naturalist, a laboratory technician, or a general bureau of information.

It is evident that only those subjects that are in keeping with the basic purposes of the elementary school succeed in maintaining a permanent place in its curriculum. The American elementary school is a unique institution. It has been called at times "the great common school," in that it is the school for all the people. It was established by the early forefathers as the one institution that would be common to everyone, regardless of race, religion, economic status, and future occupation. It has become the basic institution dedicated to the task of the education of all people for citizenship in a democracy. A significant part of the success that science has had can be accounted for by the fact that elementary-school workers have been concerned that science be developed in the interests of *all* boys and girls. This pattern for science in public elementary education is being adopted by a number of democratic countries.

Science from the Developmental Point of View

Science in the education of children should be considered wholly from a developmental point of view. Recognition will then be given to the fact that children do not come to school for the first time at zero in science learning.

They have had a wide range of rich experiences with physical and biological phenomena. They may have a variety of experiences including those with friction, momentum, inertia, magnetism, static electricity, simple electric circuits, snow, ice, water, steam, melting, boiling, freezing, conditions necessary to certain living things, care of animals, seasonal change, the sun, the moon, stars, clouds, mirrors, magnifying glasses, evaporation, condensation, varieties of kinds of locomotion found in the animal world, animal mouths, ears, noses, coverings, balance with building blocks, wagons and tricycles, heat and cold, effects of seasonal change, different animal habitats in the community, solution of solids in liquids, molds, the large number of seeds produced by some plants, and so on. They may bring with them misconceptions and superstitions, or they may come to school with a good attitude conducive to learning and the development of intelligent and resourceful behavior.

Many teachers of children find it useful to accept a point of view of dynamic psychology for understanding children. Their ideas may be stated simply in such words as these: A child lives in a dynamic universe which is new to him. He is challenged by his many experiences. This universe is filled with a great variety of objects. He is impressed by the events (phenomena) small and large occurring about him, such as rusting, rain, weathering rocks, electrical shocks, thunder, wind, and falling objects. He finds himself in normal circumstances tremendously stimulated and turns naturally to exploring and learning.

A young child is naturally egocentric. He is not to be condemned for being so; his egocentricity grows out of his great potentialities for ceaseless drive and for adjustment and understanding of his environment and himself. As a result of the great drives and yearnings, he feels inside himself a whole gamut of emotions which are to him discoveries about himself. He may display grief, irritability, anger, restlessness, impatience, and disappointment. Although such expressions are not to be condoned or encouraged in children, they are

not to be considered in themselves evil, for out of these emotional drives have come many of the great constructive developments of mankind, such as democracy, better living conditions, religious freedom, and improved health.

A child is an energy system and in all the universe we do not find its equal. It is remarkable that out of the use of his energy, a child is becoming intelligent in a universe filled with a vast variety of living and nonliving objects, an almost kaleidoscopic array of events and changes. Within his rapidly widening universe, the child attempts to identify himself and his inheritance. Viewing children from this dynamic point of view assists parents and teachers to understand that the drives of children, which are so frequently annoying to the adult, are potentially constructive traits.

A child learns about his environment whether he is taught science or not, although some of his learning may be negative in value. The kind of science learning considered in this Manual begins in the cradle. As a child begins to separate himself from his environment, he begins to develop learnings based on these experiences. Parents and teacher must recognize that there may be learning about the environment even though a child is unable to state meanings in words. For instance, a child is experiencing something with the rattle he places in his mouth although he has no words with which to shape thought. He is learning something about the earth and its gravity as he pushes his weight against it in taking his first steps. Were the earth like a suspended rubber balloon that bounced away from him, or if the gravity were not constant and pulled him with greater force at some times than at others, he would develop a different set of attitudes and behavior. In considering science in the program of elementary education, it is well to conceive of science experiences as beginning with birth. In a real sense, the adjustment to the environment can be traced back to the prenatal stages.

In a very real sense, we might say that the potentialities of science are inside human beings. To make it more personal we may think of these potentialities as being in such human beings as ourselves—teachers and children in the classroom. This is true because science has grown out of a tremendous urge on the part of mankind through the long centuries to come to an understanding of the universe.

Man, from the remote past, has sought explanations for the things that happen in the world about him. The rainbow, birth,

death, life, lightning, and other events challenged him. He frequently used great ingenuity and much fancy to develop explanations for the phenomena about him. The myths and legends of many peoples indicate men have felt that if they could understand the world about them they might know more about themselves, their origins and history. The fact that primitive people frequently associated their explanations with their religious beliefs demonstrates how important such explanations were to them. In fact, these explanations had much to do with man's adjustment to the environment. Sometimes man's explanations made him fearful and superstitious; at other times they filled him with confidence, calm, and resourcefulness.

According to the developmental point of view, the origin of science is in man's distant past. An implication of this for teachers in the elementary school is that science need not be thought of as something foreign to them or to the children they teach. Science as we know it today, with its discoveries and inventions, is the result of urges in men and women through the ages. We can see these same urges in children as they follow their natural drives and as they attempt to secure adjustment and equilibrium in a dynamic universe. They use the senses of smelling, tasting, feeling, seeing, and hearing, the kinesthetic sense, imagination, curiosity, energy, irritability, restlessness, play, response to external conditions, and other partly understood drives deep within their natures to project themselves into the areas of the environment. They depend upon impulse, fancy, creative activities, and logical thinking just as their ancestors did.

From the developmental point of view not all of science is difficult. On the contrary, from this point of view science is part of the earliest learnings of children. Furthermore, the technical, vocational, and specialized aspects of science have no function in elementary education. Elementary science is closely related to the experiences of children and to the kind of thinking they can do, so that teachers need have no fear of science. The teacher can learn the science that is needed while teaching science at any level in the elementary school.

The fear of science felt by some adults is not usually found in children. The adult may have been conditioned to a dislike of science in part by previous contacts with science instruction at high school and college levels, whereas children, having felt no such condition-

ing, are still following their natural impulses. Teachers can free themselves from their negative reactions if they will attempt to see the environment and science through the eyes of children. Encouraging children in a classroom to express themselves freely about their ideas of natural events has assisted many teachers to understand children and at the same time to gain a new look at the world for themselves.

Using Science in a Democracy

There has grown up a conviction that the free nations must remain strong if they are to remain free. There is also a realization that there is power in science, and therefore that science is an essential element in maintaining and improving the democratic way of life. It will not be enough to have a small portion of the population educated as scientists; to be truly strong, an entire nation must be conversant with science. To realize this goal, science must be placed in the curriculum as one of the fundamentals. Making a whole nation conversant with science is a task uniquely suited to the elementary school since this is the institution of all the people. It is the institution which has in its enrollment not only the future scientists but laymen as well (everyone is a layman outside his special field).

Strength for free peoples is secured through the development of good living conditions as well as military defense. Through the use of science man can do much to shape his own future, since science has tremendous potentialities for the improvement of living conditions for all.

The children now in the elementary schools will live in a world of tomorrow. Our boys and girls will live in a time of great decisions. They will need to make certain that science will be used for good and not for evil. They will need to determine how democracies can be kept secure. There will be great problems concerning the use of new and old sources of energy. Theirs will be the problems of wise utilization of natural resources, the distribution of new synthetics, medicines, and drugs, provision for health and well-being, development of materials from new sources, establishment and maintenance of research agencies dedicated to public welfare, the establishment of a balance of nature that will provide ample food and recreation for all, and the creation of a stable economy based on the natural

resources and other problems to be solved, all within a democratic framework. Through all of this there will probably be a consideration of problems of international and world co-operation.

As we seek to determine what shall be the basis for our instruction in science in the education of children, we find we must look to something more permanent than a mere teaching about objects. We make this decision because in a few decades we ourselves have witnessed a vast array of new inventions displace objects which once seemed permanent. Kerosene lamps have given way to electric lights in many places. We have observed the transition from telegraph to television. Our familiar world is in constant transition. So, although we may utilize objects in teaching children, we cannot base our curriculum on objects. We must look deeper for our basic purposes.

Some might say that our major purpose is giving children content. But the content of science, important as it is in the education of children, does not constitute the fundamental purpose of including science in the elementary curriculum. This is true, first, because our basic purpose must be in terms of children and society, and consistent with the dedication of the public elementary schools to the principles of democracy. Second, as we shall see later in this introduction, we must recognize that the content of science is not absolute; what we think is reliable information today may need revision tomorrow.

What we can be certain of is that boys and girls will need to be resourceful and democratic in the decades ahead if their and our way of life is to survive. Therefore, we are concerned with the development of resourceful and democratic behavior. If we succeed, we shall not need to be unduly concerned for the future, for with the development of resourceful behavior in accordance with the high purposes of democracy, our boys and girls can use science to shape the future with complete confidence.

It is to be noted in this discussion that science is considered as a tool for humanity. There is no intent in the education of children to develop science for its own sake or to defend science as a vested interest. Only as science serves in the development of children and in the welfare of humanity can it be defended as essential in the education of elementary-school children.

It is most important that we recognize that boys and girls need to do much more than talk about science. If democracies are to

preserve their way of life, there must be in their populations the ability to operate intelligently and resourcefully with the materials and energy of the universe to the best interest of mankind.

Social studies, however valuable they may be, are not sufficient in themselves to help children meet and solve the problems of today and tomorrow. Teachers and school systems are likely to miss the great contributions of science to children and through the children to the larger goals of democracy when they place science in the curriculum as a segment of the social studies. Science grows out of the tremendous urges of the human organism and does not have to be motivated through social studies. Many students of children think that science by its very nature is more challenging to young children than social studies. This is not to be interpreted as an argument against the social studies. It is, however, an appeal that curriculum workers thoroughly think through the concept that science is a part of the development of children. If properly guided, children can grow in intelligent and resourceful behavior just as they can grow physically if properly nourished.

Some have suggested that the primary purpose of science in the education of children is to develop "little scientists." Such an idea is not consistent with the fundamental purpose of the elementary school and the origin and nature of science in society. There should be no hero worship of scientists except in so far as an individual scientist deserves it. Democracy will be weakened if a society is created with a distinct scientific class. Scientists serve, but so do soldiers, senators, artists, carpenters, barbers, farmers, doctors, and everyone else. Scientists now and then outside their own special fields are somewhat naive, and at times exhibit traits of gullibility and dogmatism, thus violating the fundamentals of science. Scientists are human beings like other people. We should not set up the lives of scientists as ideals for children to follow, regardless of how much we may appreciate the contributions of science.

The Nature of Modern Science

In science we do not view knowledge as absolute. Any statement of science can be challenged, revised, or refuted with suitable data. There is no room for dogmatic attitudes. There can be no dictator for science.

Through science, man strives always for a better understanding

of the world. Unfounded prejudices, opinions, gossip, rumor, astrology, myths, intuition, and superstition cannot be considered reliable sources.

Science is an active, dynamic field, constantly demanding willingness to make new observations, to repeat experiments, to consider new facts, and to challenge earlier conclusions. Science is far from a finished subject; in fact, it is likely that it is only in its beginnings. All the areas of science are undergoing changes as a result of continuous study. New ideas are being added and old ideas revised about stars, ventilation, living things, diseases, nutrition, and other areas of science.

Man learns through experiences by means of his senses. Science has produced new instruments, such as telescopes, microscopes, and others, that extend man's range of observation and experience. Nevertheless, to explain many happenings in nature, even everyday occurrences, is exceedingly difficult in spite of many new technical tools. So scientists have been forced to develop provisional explanations, or hypotheses, to guide them in further study of some things. But scientists must abandon any hypothesis as soon as it is found to be unsatisfactory. There is much that scientists have not satisfactorily explained. Many times a scientist must say he does not know even about problems within his own field of specialization, and even though he may by all rights be the world's leading authority on the problem involved.

Since man is continuously in the process of making new discoveries and revising his information, accuracy is not an exact status. This means that we do not teach a fact as though it must be true for all time. It indicates, also, that we cannot teach all the truth to a child about any single subject. We may, however, attempt to make certain in the classroom that the way in which a child learns is consistent with scientific attitudes.

We cannot hastily call an item correct or incorrect. Instead it is essential that in all our discussion, reading, experiments, and so on we determine what is the most reliable information at a given time. It may not be as serious a matter to be mistaken in the information we may have at any time, as to assume that there may be no need to secure new information on all important matters throughout our lives. It is also a serious matter to pass along information as if there were no question about its accuracy when we are not sure of its re-

liability. The nature of modern science is thus entirely consistent with the idea that learning takes place through the continuous growth and development of large concepts. It also indicates how necessary it is to view education as a process which takes place from the cradle to the grave.

Accuracy is a direction toward which man in his best efforts strives. It is also a goal toward which teachers and children can move in teaching and learning; it calls for growth for both teachers and children. A child's ideas gained from science can be accurate in so far as they go, but as a child proceeds through the school, his knowledge about any one subject increases in amount and detail. In other words, we may not be able to teach children all the reliable information in science about a given subject, but what we do teach can be consistent with what is reliable. Authoritative books such as those in the SCIENCE TODAY AND TOMORROW series can be most useful to both children and teachers in maintaining a high standard of accuracy and a sound development of attitudes.

Science and Behavior

This condensed description of the nature of science has been provided because it has many implications for the teacher and can provide him with a sense of security and adequacy in teaching children. The teacher has the right according to science to play an honest role in the classroom. He has a right to admit that he is learning; that he makes mistakes sometimes; that sometimes a child with a special interest and concentration may be learning faster than he is. In a real sense, the scientific method is a method of honesty, and neither teacher nor child should be penalized in any way for being honest. The learner should never be humiliated for the admission of ignorance. The implications of science for mental hygiene and human relations are profound.

It would be well for the teacher to consider the implications of science in the development of such behavior patterns as open-mindedness, critical-mindedness, and the avoidance of gullibility. There is no greater educational factor operating in the modern world than the attitudes that teachers and parents utilize while working and living with children.

In science it is important to state the source of one's comment in explaining a phenomenon, such as evaporation of water, hiberna-

tion of animals, erosion of soils, and so on. For instance, one might say, "I read an explanation in . . . ," or "It may be . . . ," or "My father said . . . ," or "On my way to school I saw . . . ," or "I think it might have been," or "I used my imagination," or "I think I am right," or "I can do an experiment to show . . . ." This is preferable to giving such information as if the statements were unquestioned facts. We have sometimes called this identifying the source of a comment. The teachers and children should develop the behavior pattern of identifying the source of a comment.

Both teachers and children have a right to use their imaginations, to speculate, to repeat information as long as they distinguish between reliable and unreliable information. Such a behavior pattern is in the direction of assuming responsibility for one's own speech. It is quite different from the behavior of gossip, loose talk, and rumor spreading.

This type of development should not be allowed to harm the good human relationships of children. Frequently children use parents' opinions as reliable information. It would be well for the teacher to handle such comments in a manner that will in no way decrease the child's respect for his parents. In a sense, the attitude of the teacher may be that we are glad to have what the parent has said, and indicate that further development of the statement is given in authoritative books. Perhaps the comment might be, "What do persons who spend their lives studying this kind of thing say?" Science instruction should be utilized to improve the human relationships of children, those of children with children, children with teachers, and children with parents.

It is obvious that the great behavior patterns growing out of science are not built in a finished manner in a day or a year or a decade. For instance, critical-mindedness and open-mindedness require time for development. Development of the patterns associated with resourceful, democratic behavior should be considered a continuous program throughout the elementary school.

There is considerable evidence that three great achievements of mankind—democracy, scientific method, and religious tolerance—developed contemporaneously and out of the same general struggles. An examination of these achievements will indicate that these three have much in common in basic meanings. In the opinion of many students, real science cannot exist outside a democracy.

The Content of Elementary Science

Almost everyone is impressed with the extensive nature of science; it has indeed grown tremendously in scope. No one can learn all of science in an entire lifetime. It is also obvious a teacher cannot teach it all. Only a very small portion of the total science will be taught to children, but that portion can be most important in the development of citizenship. The question of how much content of science is taught is not of nearly so great importance as is the question of what content of science is taught and how it is taught. With the world situation as it is today, it is most important that the content and procedures of science suggested to teachers and children in such a series as SCIENCE TODAY AND TOMORROW be those designed for the preservation and advancement of democracy.

Because of the extensiveness of science, there has been a tendency to develop what might be called encyclopedic instruction. Under this method students have been required to learn wide areas of content. Comprehensive instruction has been developed about animate and inanimate objects and about topics in the environment, with little sensitivity on the part of curriculum makers as to the value of the content to the teacher and children involved. In the encyclopedic type of instruction the purposes of science in elementary education became lost in small content and busy work.

A traditional trend in nature study has been to make science instruction dependent upon an incident approach. If a child brings in an object, such as a rock, a feather, or a flower, or if he can relate an interesting experience, then there is instruction in this field about the object or incident. If there is no object or no incident, there is no science instruction in such classrooms. Science becomes incidental and accidental in the classrooms of teachers holding to this point of view.

But science is no incident in the lives of children. In fact, it is and probably will continue to be one of the most dominating and decisive factors in their entire lives. Schools developing science on an incidental basis will not provide boys and girls with the education they need for the great decisions they must make for themselves, their country, and the world.

This is not to say that incidents have no place in teaching-learning situations. Natural incidents can be used as experiences for concept-

formation and for the development of understanding of phenomena. But science with its profound and challenging ideas has a great contribution to make to the formation of concepts and important ideas. If our democracy is to survive, we must make certain that the potentialities of science in our way of life will be developed. This instruction must not be incidental.

Since the best information scientists have at any one time will need to be revised in keeping with future discoveries, a content of science in the elementary school cannot be considered as set and fixed for even a few years. There are, however, certain patterns for the universe which seem to persist as profound descriptive principles for all time, in spite of revisions and modifications that follow new discoveries. These patterns are described in the following statements:

a. The universe is very large.

b. The earth is very old.

c. Many changes are going on in the universe.

d. Living things are interdependent and interrelated.

e. Living things which are living today are the results of adaptations that have been made in the past.

f. There is a great variety among living things.

g. There is evidence of a tendency toward balance among the forces and living things.

For the sake of brevity, we can speak of these patterns as principles of space, time, change, interrelationships, adaptations, variety, and balance.

These patterns seem to be guide lines for instruction through the elementary school. A child can continue to grow along the lines of these great principles or patterns. The experiences an individual has throughout life can enrich his understanding of these principles. Man must recognize these patterns if he is to adapt his civilization to this universe. A knowledge of these basic patterns is necessary to the understanding of the world's problems and life's experiences in our modern democratic world.

The Large Patterns of the Universe as Guide Lines for Teaching-Learning

The Universe Is Very Large—Space

As man has studied the universe that surrounds the earth, he has become impressed by the immensity of space. The earth which he thought was very large and the center of everything is small compared with many other objects in the universe. This earth is one of several bodies which revolve about a star known as the sun. The sun is one of millions of stars which compose a vast galaxy of bodies which is called the Milky Way. Man has learned that there are many other galaxies within range of the modern telescope.

While a complete understanding of the immensity of space is undoubtedly beyond the mental capacities of any one individual, it can become a guiding factor in the interpretation of the experiences of children at all levels. The young child may begin his growth in the understanding of space as he begins to associate with himself the rooms in his home and the yard or immediate vicinity about his home. Later, he learns the location of the nursery school or kindergarten when he is taken there by adults or by school bus. Still later, he goes to school by himself and learns where the homes of his relatives and friends are in relation to his own home. As he travels to neighboring communities, his world becomes larger. He may be intrigued by the observation that the sun and moon seem to follow him as he moves about.

A child's early contact with this pattern may merely teach him that the earth is a very big place compared with his familiar neighborhood. He may become acquainted with the appearances of the day and night sky. Later, his learning will reveal that the earth is very small in comparison with the stars and space. About the same time he will also learn that the stars are suns which are very, very far away. In later years he increases his understanding of the vastness of space by learning about the extent of the solar systems, the Milky Way Galaxy, other galaxies, radio stars, cosmic rays, the light-year, and so on.

Any adult who has read modern astronomy, has attended lectures in this field, visited an observatory or planetarium, or considered the possibilities of space travel knows that his conception of

space continues to change after childhood. There are new, challenging thoughts for all levels—the junior high school, senior high school, and college levels—and, for that matter, many new discoveries still to be made by the astronomer. Some comprehension of this conception is essential to an appreciation of the significance of science in its revolutionary effect on modern thought. It is important that children should be started properly along this path rather than allowed to absorb inaccurate and unscientific ideas of the universe and astronomical bodies and to grow up with earth-centered conceptions in an age of modern science.

The Earth Is Very Old—Time

The conception of the great age of the earth and of the universe has come to mankind as a revolutionary idea. Not only has it profoundly influenced scientific understanding, but it has altered man's attitude toward his own place and function in the universe. It was natural for primitive man to think that the earth had been formed just a short time before the advent of his people. Much of this primitive belief came down into modern times and still controls thought in scattered areas. Children in their early years may learn that soil is made from rocks, and through activities, observations, and experiences discover that the process of soil formation took a long time. They may also learn something about the forces which operate upon the earth to produce changes; that it was a long time before the earth became a suitable place for plants and animals; and that many kinds of animals have lived on the earth and have become extinct. These ideas furnish him useful content in constructing his understanding of the great age of the earth.

Children may have a variety of interesting experiences with earth forces: for example, they may examine pavements broken by water freezing in winter; feel rocks softened by the action of weathering; observe erosion after a rainstorm; note how plants keep soil from eroding; examine different kinds of soil with a magnifying glass.

Time is something to be learned. Children must learn the concepts of yesterday, today, and tomorrow; the meaning of a second, a minute, an hour, a week, a month, a season, and a year; the sequence of seasons; the varied lengths of life of living things. A tree may be several hundred years old, and on the other hand, a moth may live only a few weeks.

Time is relative to both children and adults. A half hour may be a long time waiting for a plane or train, but very short if we are playing. A year between birthdays can seem a long time, but it is short in terms of the centuries the Indians have lived in the Western Hemisphere. The teacher and the parent can greatly enlarge children's concept of time.

In later work children may learn something about what has happened to the earth, the causes of natural features in various localities, the long ages of prehistoric life, the struggle of life for existence, the forces operating on the earth, and some of the changes that have taken place on the surface of the earth. This comprehension of the great age of the earth is essential to an appreciation of the antiquity of man and of man's attempts to build social institutions for his own welfare. The goal is not the memorizing of a chronological sequence of events, but rather an approach to the modern conception of time. These ideas reveal to man the importance of building his social and political structure with the thought that he may live on this planet for some time to come, provided he uses his intelligence to assure survival. These concepts are fundamental to building an understanding of what is intelligent utilization of natural and human resources. This understanding is necessary for man's planning for his own future.

This background to an appreciation of the modern concepts of time and change should tend to inhibit chauvinism; it should teach each pupil that all life existing on the earth today is the result of a long succession of living things—a development involving a vast number of individuals and extending back to the beginning of life on the earth.

The mountains, rivers, valleys, plains, seas, and other physical features that we think of in connection with a given nation and that often come to be revered by the people of that nation have not always been there as they are now. The surface of the earth has changed its appearance many times in the past and is constantly changing today.

As the result of a long series of experiments in the art of living, man has become a dominant force in nature, and we have a right to feel a pride in the achievement of all mankind. It must be emphasized in our instruction that this achievement is restricted to no one race or nationality.

Changes Occur Continuously in the Universe—Change

The conception of change permeates all fields of knowledge, and man must consider these changes if he is to operate intelligently with natural forces. Modern geology reveals that our physical environment does not remain constant, that the history of the earth is a story of change—change in climate, in topography, and in the succession of living things.

The conception of change is manifest not only in geological history but in living things, as, for example, the changes produced by birth, growth, age, and death. There are also changes produced by the biological principles of struggle for existence; and these cannot be ignored by man in his striving to adapt the world to his needs. Then there are the changes produced by energy and movement. Astronomical bodies are seen to have changed position and character through cycles of time. The scientist learns to look for change in his explanation of phenomena; the layman must expect change as a condition of everyday life; the student of social studies and the citizen must anticipate change in the political, social, and economic structure. Information concerning changes produced by physical and chemical phenomena, developed in terms of children's own experiences, can be introduced during early school years and continued through later levels.

Children see water disappear from a dish by evaporation. They pick up rocks which have weathered so much that the rock disintegrates into small pieces in their hands. They see the changes in the sky, in the weather, and in seasons.

Illustrations of change include such phenomena as rusting of iron, melting of ice, boiling of water, weathering of rocks, variations of weather and of seasons, and innovations produced by man's discoveries and inventions.

School windows should be utilized more fully for the study of the succession of changes due to weather, to the seasons, to the time of day, and man's activities in relation to these changes. Brief excursions around the school ground will provide varied experiences depending on the region. The children may see frozen, muddy, and dry soil; the growth of plants; and a variety of plant structure, such as roots, stems, flowers, and seeds. An outdoor thermometer may reveal temperature changes. Art work can be utilized in the study of changes.

A community of living things never remains in a strictly static condition. Children can observe the changes in a weed patch near the school, in a thicket, or in a garden. There is a continual shifting caused by weather, seasonal change, and just ordinary life and growth within the cycle of new life, maturing, and death. All around children are evidences of change.

There is no exception to the occurrences of change even when man is involved. Natural forces are always present and working in an environment. Perhaps man can never control the natural forces. Rather he must learn to work intelligently with these natural forces to bring about changes which are advantageous to his best interest.

In addition, there are the great changes brought about by man's inventions and man's discoveries. Of course, children are not so aware of the significance of these changes as adults. However, the school must prepare children to meet change, for the next generation may need to be prepared for even greater changes than those met by the present generation of adults.

Man has lived through revolutionary changes in his social living because of the introduction of new forms of energy and of ways to utilize that energy. The discovery of fire, the introduction of animals to carry man's burdens, the steam engine, the electric generator, and the internal-combustion engine greatly changed man's social and economic conditions. The utilization of atomic energy is bringing and will continue to bring tremendous changes. Children should gain a feeling of confidence in the fact that they are not the first of the human race to witness revolutionary changes in energy. Furthermore, it might be well for us to know how man's discoveries of new forms of energy have brought about great potential supplies of energy for everyone. The advances in the field of agriculture and soil culture may have significant impacts on the future course of world events.

Changes brought about in a community also may be significant. What did the country look like before the earliest settlers came in? What changes have been brought about by man?

There are only about a hundred elements which enter into combinations and form the multitude of substances about us. Chemists find that some of these elements combine in so many different ways that to date they have been able to make but a small proportion of all the possible combinations. Chemists are learning to build

out of cheap sources substances which in their natural states have been very rare. They have also learned how to make new substances, such as new drugs, insecticides, medicines. plastics, synthetics, and so on. In this way, science contributes greatly to an improved health, finer recreation, and higher standard of living.

Life Is Adapted to the Environment—Adaptation

Adaptation is a pattern which permeates the entire realm of living things, for wherever there is life there is adaptation. This is a conception of great significance in the modern world. Indeed, man's problem today is to adapt his social, economic, and political structure to the conditions of the environment and his own needs. In the early grades children can learn something about the homes of some animals and their adaptation to life in various places. They can be introduced to the idea that animals' structures have become modified to fit their environment. Later they can learn how plants and animals, including man, are adapted to seasonal changes. The study of prehistoric life is a story of adaptation, and can be supplemented by a study of how animals are protected against their enemies, how animals take care of their young, and how plants continue to live on the earth. Man adapts himself through community life. The advantages and disadvantages of this form of adaptation, along with a study of solitary animals, may be considered on intermediate levels. As the child matures, the scope of his concept of adaptation is further broadened through a study of prehistoric modifications, of the weapons which animals use, and of the struggle for existence.

The conception of this pattern, like the conceptions previously outlined, may influence an individual at all levels of his development. It may modify the child's interpretation of simple observations of the effect of seasonal change on plants and animals. It may give substance to the youth's understanding of the structural variations of living things, and to his consideration of problems of public welfare. It may determine the adult's participation in politics and in public forums. The scientist finds much that remains to be discovered concerning adaptation. The significance of this conception in the social studies can scarcely be overemphasized.

Some of the more general facts involved in understanding the concept of adaptation are the relationships of living things to tem-

perature, water, food, light, gravity, and certain gases found in the atmosphere; the effect of some of the limitations of these conditions upon life; the narrow range in these conditions on the earth as compared with those found in the universe as a whole; the adaptations imposed upon plants and animals that live under these conditions; the prolificness of life; and the interchange of energy and substance between plants and animals and between the physical environment and living things. Through experimentation, discussion, and reading, children learn that living organisms need light, oxygen, nitrogen, carbon dioxide, heat, water, and other conditions in order to exist and to produce young. When some of these things are scarce or too abundant, life may suffer.

The implication for international understanding is that man frequently is limited by the physical conditions of the environment to which he adjusts himself. Some people must live in inhospitable places, such as swamps, deserts, and arctic regions. These people must utilize the materials that are available for shelter, food, and clothing. It is not surprising, therefore, to find among the peoples of the earth a wide variety of customs. Many of these customs which seem foolish to others may be the results of the experiences of many generations in a given environment and may be necessary to the survival of that people.

International co-operation has become a necessary adjustment on the part of mankind if our culture is to survive.

In science studies in the elementary school, children have an opportunity to realize that man is only one of a multitude of living things, and that, like these other things, he has survived because he has made adjustments and adaptations to the environment.

The Variations of Living and Nonliving Things—Variety

On the earth there are wide varieties of climate exhibiting differences in mean temperature, in the range of temperature, in the length of the growing season, in the amount of rainfall and its seasonal distribution, as well as differences in exposure, in slope, in drainage, in elevation, and in soil. These factors create many kinds of environments and require adaptations to these environments. All around us we see in nature a variety of forms, differences in structure, sizes, habits, and life histories of plants and animals. They range from the ultramicroscopic organ-

isms to the gigantic forms of the redwoods and whales. The life span of some living things is very short, while that of others covers several hundred years.

When we see how many different kinds of living things there are, it is not surprising to find that there are also so many different kinds of people. Man has wandered about the world for thousands of years, living in many habitats widely separated from each other. We should expect, therefore, to find different races, languages, and customs, but a concept that science may teach is their interdependence despite their differences.

No two living things are exactly alike, although they may be of the same species. We cannot, therefore, judge all people of any nation on the basis of one or two we may have known.

Variation is manifested in the physical world as well as in the biological. There are many systems of organization in the physical world—the atom, the element, the molecule, the compound, the substance, the planet, the solar system, the galaxy. There are many kinds of minerals, soils, and rocks. There are only about one hundred elements; but there are thousands of different compounds. There is variety in the manifestations of energy. Man, too, tends to develop variety of forms in his inventions, discoveries, engineering, and arts.

Children should become acquainted with this theme by being introduced to the range and scope of certain obvious characteristics in the physical and biological aspects of nature. Instruction should be chiefly concerned with the theme rather than with mere identification of animate and inanimate objects.

Each child has two parents. Each parent brings to the child a diverse inherited background. When we consider that this means for each child four grandparents, eight great-grandparents, and so on, the tremendous potentialities working for variation in the human race become apparent. When to this observation we add the fact that each child has a different environment, the tremendous variations found in children in any classroom are understandable. Every individual is a result of success through a long span of years in that each of his ancestors is the result of two parents reaching maturity in spite of sometimes hazardous conditions.

The concept of individuality, that each individual is unique and different from all other individuals, is a part of the larger pattern of

variety. Williams,[1] a biochemist, has recommended that we should start teaching children in the kindergarten that they possess individuality. His recommendations merit serious consideration by elementary-school workers. They point to one way in which science can contribute to mental hygiene. Each individual has a right to be different. He should not be amazed to learn he is superior to some of his classmates in some ways and inferior to others in other abilities. This pattern can be used to develop a feeling for the dignity of the individual, a feeling so important in a democracy.

Following are some of the aspects of variations that are illustrative of those found in the environment of children:

Changes that take place in the out-of-doors.
The many different kinds of animals.
The variety of animal noses, eyes, tails, mouths, coverings, legs.
The variety in prehistoric animals.
The different ways in which animals move about.
The differences in animal homes, such as those on the desert, in the arctic, in swamps, underground, in fresh water, on the seashore, in the ocean depths, in the forest, in the meadow, in trees.
The variety in locomotion, food-getting, breathing, and protection of animals.
Different ways in which animals grow up.
The many different kinds of plants, such as those that develop from spores, those that develop from seeds, those that are annuals, those that are biennials, those that are perennials.
The animals that are social, and those that are solitary.
The animals that are cold-blooded, and those that are warm-blooded.

Interdependence of Living Things—Interrelationship

A theme which is practically universal in character is interrelationship. We see the significance of interrelationships as an integrating theme in many of the forces operating on the earth, for example, in the description of astronomical bodies, weather, and other physical phenomena; in the interdependence and interrelation of living things to each other and,

[1]Roger J. Williams, *Free and Unequal: The Biological Basis of Individual Liberty* (Austin, University of Texas Press, 1953), p. 177.

in turn, to their physical environment; in the causes of ill health; and in the relation of pests and parasites to economic loss in the agricultural world.

Space does not permit a full discussion of how the idea of interrelationships in physical and biological phenomena may be developed. In the early years children gain experiences which lead to an understanding that some plants and animals in the garden are harmful. In later work they learn the value of certain other plants and animals and what people are doing to protect them. Attention should be focused in later elementary-school work on the problem of conservation and on preparing pupils for a more comprehensive study of the biological principles involved in the struggle for existence, in the balance of nature, and in the interdependence of life. Some of the relationships of scientific discoveries and inventions to man's progress and welfare should be considered. Man does not live to himself alone. He lives in a world of interdependencies and interrelationships. He is dependent upon earthworms and plants for the fertility of the soil. He is dependent upon the birds to keep the insects in check. He needs snakes, owls, hawks, and other animals to keep rats and mice in check. Spiders serve to control the number of insects. An animal which seems rather insignificant to us may play an important role in the development of conditions suitable to man.

The interdependence and interrelationships of living things to other living things and of living things to the physical environment is basic to the understanding of social issues. Physical and biological forces do not recognize national borders. A wind blowing in one country may be due to world-wide atmospheric conditions and the pressure of air in regions within the borders of other nations. Animals do not necessarily stop at national borders unless those borders are natural barriers, and even then certain animals are known to cross many such barriers.

In science the earth must be considered commonly as an entity; a disturbance in the physical or biological world in one part of the earth may have significance to many other parts. In a community a fire in one section is the concern of the entire community. A disease or a pest in one section of the world may become the concern of all peoples. Nations, therefore, should learn to work together in an intelligent way for the welfare of all peoples of the earth.

The natural resources of a country, such as soil, oil, coal, gas, forests, and pastures, are the result of natural forces operating for millions of years. People have not created them, but they frequently waste them through carelessness and mismanagement. Man can waste in a generation or two what has been the result of titanic natural forces operating over long periods of time.

Man, if he is to remain civilized, must disturb the original balance of nature, for only savagery can exist where man does not attempt to make changes. But it is man's task to use the natural processes and resources in such a way that he secures what he needs for a high standard of living without hazarding the welfare of future generations. Man need not return to savagery nor disregard natural resources; he now has science to use in planning for the years ahead. It is incumbent upon the public schools to develop a generation with ability to meet its problems, both personal and social, with intelligence, co-operation, and resourcefulness. This calls for an appreciation of the interdependence of living things, and of the interrelations of living things and the physical forces and materials.

Balance and Imbalance—The Interplay of Forces

As one observes the many events or phenomena in his environment, one is impressed by the dynamic flow of events and the energy involved in them. If one could be an observer over centuries, one would be aware of the titanic forces in operation; but seen one day at a time over the short span of a human lifetime these forces often pass unrecognized. Some, such as evaporation, seem small; yet scattered over the face of the earth, evaporation is tremendous and results finally in rain, snow, dew, frost, weathering, erosion, floods, blizzards, and other events.

There seem to be tendencies toward equilibrium and balance in the operation of forces. In a normal atom it is thought the positive electrical charges balance the negative electrical charges. It is thought that a static electrical charge is the result of an imbalance in these electrical charges. The shock we feel or the lightning flash we see is the resulting establishment of equilibrium of these charges. Even the thunder can be thought of as a clap caused by air rushing in where the air was expanded by the heat of lightning.

We have already spoken about the balance of nature. Man has

been ruthless at times with this balance and has experienced economic loss from the resulting dust bowls, soil erosion, waste of resources, epidemics, plagues, and pests.

There are forces operating also in the structure of the earth. It is thought by some geologists that in maintaining balance these forces have caused the formation of mountains, continents, and oceans. We witness earthquakes and volcanic eruptions as a part of the balancing of the earth's structures.

It should be kept in mind that the sun is a great source of energy and that it shines on the earth all the time. It shines on the other side of the earth while we are having night. It shines when it is cloudy, although there are clouds between us and the sun. The sun then is like a great solar engine which furnishes energy for green plants to grow and make food, for water to evaporate, and for the movements of air currents or wind and of ocean waves. The movements caused by the sun's energy are checked and modified by the earth's gravity, its rotation, and to some extent by friction. There is a tremendous interplay and interaction of the forces in the universe.

Wherever we look we witness the operation of forces and the many evidences of balance. In our own efforts to maintain balance and equilibrium, we also experience the operation of natural forces in and on our own bodies. Many psychologists explain learning at all levels as a process of attempting to gain intellectual balance in the face of a new situation, a problem, or a challenge.

Conservation as a Pattern for Behavior—Developing Responsibility for Our Environment

As children develop a better understanding of the basic patterns of the universe, they also may acquire more intelligent behavior with reference to natural resources, including human resources.

Some courses of study help to establish undesirable kinds of behavior, as when children are encouraged to develop collections which in turn can rob the environment. Sometimes they are instructed to bring to school collections of leaves, twigs, flowers, rocks, minerals, and bird nests.

We need to develop in children a feeling of responsibility for the environment. Conservation, or intelligent use of natural resources, consists of a kind of behavior as well as a body of content. Before moving objects, animate or inanimate, out of the environment and

into the classroom, there are many major considerations which the children may discuss. To whom does the object belong? Do I have the right to take it to school? Do I disturb the environment if I remove this object from it? Am I destroying the natural beauty of the environment by removing this? Is the study I am going to make of the object one which merits its removal from the environment? Should I plan to return the object to the environment as soon as the study is completed? Can this object be studied properly if it is removed from the environment? Can I care for it properly in the classroom? If it is alive, does it have a chance to live in the classroom? Am I prepared to give it the care it needs to survive? One should keep in mind that living things are usually found in an environment to which they are more or less well adapted.

Developing Behavior Consistent with Health, Economy, and Safety

Many schools are now integrating health entirely with science and the social studies. Science provides the necessary background for the teaching of health information and the development of good health habits; therefore, a program of science in terms of problems and meanings should offer opportunity for the integration of science and health.

The relation between science and economy has too long been neglected. Because of his own ignorance of the operation of biological and physical principles, man is at present beset by a host of problems concerning international economy. Recent projects in a number of countries are helping to solve these economic problems in local environments by re-establishing in the natural forces a balance in favor of man's interests and welfare.

The relation of science to the economic problems of man is well exemplified in his struggle with pests. Man has carelessly introduced exotic plants and animals into almost all regions of the world. Many of these transplanted plants and animals, unchecked by their natural enemies and competitors, have multiplied so rapidly that they have brought havoc to the economic life of the nation. Control comes not alone from the work of fact-finding public or private scientific agencies, but also from the intelligent co-operation of the entire population. Much can be done to secure this intelligent co-operation through an integrated program of education in the public schools.

Mankind cannot afford to have another generation ignorant of the elementary biological principles of nature.

Another similar problem is to find ways to prevent loss of soil through erosion. In almost any section of the world we can find examples of the terrific loss of natural resources resulting from the lack of soil conservation. Creating an awareness of this problem in order to bring about intelligent individual and community action concerning it is no small part of science in the elementary-school program.

Many species of our indigenous plants and animals have become extinct because of man's ruthlessness and ignorance. Still others are in danger of being destroyed. Man cannot continue to be ignorant of the web of life in which he is by nature involved. The elementary school, as the tool of the common people, should work toward developing a generation concerned with the wise utilization of natural beauty and resources.

We cannot fully anticipate the environment of the future. New inventions may eliminate present hazards and create new ones, making it impossible for us to develop a code of conduct in safety instruction which will be functional for an entire life span. It may be well for us, then, in safety instruction, to place more emphasis upon scientific principles which are basic to safe conduct. Children at all levels should be encouraged to enter into planning with the teacher for safety on all excursions, including the short excursion, even though it may be only to the edge of the school grounds.

Consideration should be given to what one should do in case of fire or other disaster so that the behavior is automatic. Classroom teachers and parents can have a powerful influence over the destiny of whole regions and nations by developing in children a willingness and ability to base their conduct and behavior upon sound information. Safety education, as one aspect of the goals of conservation, can well be integrated into the development of responsibility for one's own behavior and for the environment.

A Variety of Procedures

The teacher should look to a variety of procedures in teaching science. It might be well to avoid dropping into routine methods. Discussion, instructional excursions, observations, experiments, reading, use of visual aids, group work, and planning all play a part

in the teaching-learning situations in science education. The teacher should consider her own interests, tempo, and rhythm along with those of the children. It is important that the teacher be happy with the procedures. It is well for the teacher to be present as a participant in all the procedures. He should be a learner, for good teaching in science involves learning.

If there is one term that can be used to specify the kind of instruction appropriate to all phases of science teaching in the elementary school, it is "developmental." In this case it is developmental from the point of view of children and teacher, both as learners. It means the instruction develops, using the experiences and knowledge children may have or that can be provided for them. It is developmental in that children may participate in the development of the planning for the use of experiences, experiments, discussion, and authentic materials to provide solutions to problems. The new learning is made acceptable to the children by the nature of its development in instruction. Children are given time to internalize new learning, integrating it with their experiences and ideas. It is important in this development to provide opportunities for an idea to be tossed about in the thinking of a group, to be tested through simple experimentation, if appropriate, or through observation, to be talked about at home, and to be checked against authoritative books.

In any consideration of teaching methods, the primary concern in elementary education is what kinds of boys and girls are being developed. All of us need to be cautious that our procedures do not become devices and ends in themselves. Therefore, evaluation should be an integral part of instruction rather than something done at the end of a period of instruction.

At all times in teaching it is well for the teacher to know at what point the children are in a given development. In this Manual suggestions are given the teacher as to ways in which he can secure this information. It is well also to find out how the children think, that is, the type of thought structure they have. Such questions as "What do you think?" "Do you think so? Why?" "Why do you say that?" "How would you get the information?" "Do you think that is information we should accept?" will give the teacher evidence as to how children think and where they are in their development.

Regardless of how the instruction at any point is initiated, vital teaching recognizes the concepts children may have on a subject or

problem. So it is well for the teacher to provide opportunities for them to express their ideas, however incomplete or inaccurate, in order that misconceptions may be brought into the open. It is most important that they be allowed to express themselves without the fear of censure or ridicule, although at times there can be the enjoyment of childish humor and fun without personal damage.

Very frequently children's concepts have originality and imagination. Their concepts also provide opportunities for evaluation of preceding work and reveal the kind of instruction needed for the clarification of ideas. The authors of this series have profound respect for the natural ideas developed by children. Every child needs an adult who will sympathetically and intelligently listen to him. If such a person could be provided for more children, we would need fewer corrective institutions.

Studying Children while Teaching Science

Teachers will find their teaching enriched if they will study children as they teach. Science with its challenging content and its rich contribution to the attitudes and behavior of both adults and children offers unique opportunities for the study of children.

The greatest concern in studying children is not how much information children have secured, important as that may be. Rather, the main emphasis should be on what kind of boys and girls we have. What kind of thinking do they do? What are their outlooks upon the world? Are these outlooks constructive and democratic? Do the children think for themselves? Are they developing good ways of thinking? Are they learning to be resourceful?

At all times teachers should be alert to the kinds of behavior changes that children are making. The teacher may ask: Are the children developing dogmatic attitudes, or are they willing to consider new ideas? Are they tending to accept every idea they hear without hesitation? Do they look for further evidence before drawing conclusions? Are they learning to use authoritative books? Do they report on out-of-school experiences in a wholesome way? Do they propose explanations? Are they learning to plan? Will they work with others?

In this kind of study it must be recognized that behavior may reflect the home and the general background of the children. A dogmatic parent may cause a child to be gullible.

It should be kept in mind that it is the behavior in which a child has had some degree of freedom of choice which is the most useful for evaluation. The closely worded or directed question of the quiz program and the rigid recitation have little significance in evaluating behavior. In a sense it is the spontaneous behavior of children—the proposal of something to do, the inquiry, the choice of language in indicating open-mindedness, the critical-mindedness, poise, resourcefulness, the challenge of a statement, the willingness to consider new ideas and to take on new duties, the use of old learning in new situations and learning—which is useful in evaluation. All of this seems to favor a type of discussion in science instruction which allows for freedom of expression and thinking.

It is recognized in this that teachers need to study children as individuals and as groups and from a total, rounded-out point of view of education. The contention here is that science with its profound meanings offers unique potentialities in studying children from this view. Children should not be evaluated as if the development in behavior relating to science were isolated from all other aspects of their lives. Science, as the interpretation of the environment, should be thought of as an intrinsic part of the life of children in the modern world, a part that may be an important factor in building desirable behavior.

A Dynamic Education for Children

The preservation and advancement of democracy depends to no small extent on the behavior patterns developed in children. We do not know what the future will be. In a sense we must educate children for uncertainty. This does not imply that we need be pessimistic about the problems these children will face in the future. Rather, we can be confident that if we assist them to develop democratic and resourceful behavior, they will make their own future.

It is the contention here that the outlook of children toward their environment and universe is the very core of the development of a resourceful adjustment to the future. While incidents play an important part in making learnings meaningful, science should not be incidental in the lives of children. Instruction limited to talking about science and a description of objects and events is not in keeping with the dynamic urges of children and will not serve to help them cope with the problems of today and tomorrow.

There is a need for a positive and dynamic program for children, one which develops a feeling on the part of children of being needed by our democracy, in times of peace as well as war. Children are needed not alone for their own nation but to assume responsibility for work toward a better world.

There may be opportunities for children and teacher to work to improve conditions in the classroom, in the school, on the school grounds, and in the community. In this way, they can see how science is used.

Science will continue to play an important role in the lives of our children. It is a powerful tool which can be used for good or evil; and children, the adults of the future, will have to decide which way it shall be used.

It is most important to the success of our way of life that children have a favorable attitude toward science. Science should not seem foreign or exotic to them. Science viewed as the result of the age-old drive of man to adjust himself to his environment and to maintain his own equilibrium in the welter of biological and physical forces carries with it a larger point of view than a purely vocational one. Science is the result of man's experience and logical thinking through the centuries. Science, like democracy or the mother tongue, belongs to all who wish to make use of it. Children should be made to feel that science belongs to everyone.

Science instruction should be a pleasant experience for both teachers and children. Teachers should feel relaxed with children while teaching it. Interest in science should be maintained at all levels. The instruction should be freed of assignments involving busy work and meaningless drudgery. Exhaustive and overly specialized units should be avoided.

Boys and girls must learn to handle and to experiment intelligently with the forces and materials of the universe. Unintelligent tampering and carelessness bring disease, ugliness, waste of natural resources, unemployment, poverty, war, and widespread unhappiness. Children must develop a poised, well-balanced, yet realistic outlook upon the modern world. They must learn that by working resourcefully and intelligently they can create their own world.

GERALD S. CRAIG

Purpose and Plan of *Experimenting in Science*

As a group, teachers have become increasingly aware of the importance of science in our democracy, in all the things we have associated with our culture, and in our world as a whole. Children interact with this world of ours and through this interaction build meanings.

Many of the ideas which the children build through their experiences stem from the area called science. The behavior that results derives from this area also. In the past, too much emphasis has been placed on evaluating children's concepts on the basis of what is wrong with their ideas. Teachers in the elementary school have long recognized that it is important to know when children's ideas are in error. However, it is equally important to balance this with an approach which stimulates positive growth of children's ideas and a reasoned, well-poised basis for their actions.

This growing feeling of teachers in the elementary school has been discussed in great detail in the Foreword to this Manual. *Experimenting in Science* has been based on the purposes of science in childhood education as presented in the Foreword.

In so far as possible this Manual has been designed to place as much pertinent information at your fingertips as is feasible. We recognize how many demands there are upon you as a classroom teacher. This Manual should not add to your burdens. It is our desire that the Manual should help to make science an interesting and rewarding experience for you as well as for your children.

The content of *Experimenting in Science* has been selected as particularly appropriate to the interest and capabilities of eleven- and twelve-year-olds. In addition, three clearly defined criteria[1] have formed the basis for selecting the content of *Experimenting in Science*:

1. The content has been selected from those scientific conceptions which, when understood, greatly influence the thought reactions of the individual and which have modified thinking in many fields.

[1]Craig, Gerald S., *Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School* (Bureau of Publications, Columbia University, 1927), pp. 6–7.

2. The content has been selected from those goals (information, skills, and habits) in science which are important because of their function in establishing health, economy, and safety in private and public life.

3. The content has been selected from those facts, principles, generalizations, and hypotheses of science which are essential to the interpretation of the natural phenomena which commonly challenge children.

Plan of *Experimenting in Science*

Energy, its importance and its effects on plants, animals, man, and the physical environment, forms the central theme of *Experimenting in Science*. The first chapter, *Energy Everywhere*, gives a general, over-all view of energy. Such concepts as those of sound, light, heat, electrical energy, atomic energy, the release of energy from fuels, the sun's energy, the use of energy by plants and animals, and energy sources in the earth serve to orient children to the wealth of energy with which they are surrounded. This first chapter develops a broad picture of energy. It is intended as a "working picture," the nature of which is schematic.

As you and the children work with the succeeding chapters, material is provided through which the schematic picture of energy can be given detail which is full and rich with depth and perspective. For example, the discussion of the sun's energy in the first chapter is explained further in the second chapter, *Why the Seasons Change*. The relationship of the sun and earth is developed to show why we have seasonal change on the earth. This is approached through the concept of the way energy from the sun varies in relation to areas of the earth. In the third and fourth chapters the picture is given more detail in terms of the way changes in energy on the earth's surface affect plants and animals living on the earth.

Each succeeding chapter gives greater depth to the meaning of energy and as a result to the working picture of energy which the child is evolving and filling in as part of his conceptual growth.

An inspection of the contents of *Experimenting in Science* will show the wide, diversified areas which are considered:

Energy Everywhere
Why the Seasons Change

Energy and Plant Growth
Animals and Seasonal Change
The Milky Way and Beyond
Light Energy All around Us
Plants and Animals Live in Communities
Using Water, Soil, and Forests Wisely
Our Earth—A Huge Magnet?
Machines to Direct Energy
The Earth's Airways and Beyond
Making the World a Healthful Place

Energy is the unifying theme which ties together these various areas into a comprehensive, understandable whole.

The sequence of chapters has been developed as a result of knowledge and experience with eleven- and twelve-year-olds as they cope with such materials. You may wish to use the chapters in this order. However, you should feel free to change this arrangement if it seems wise to do so as you work with your children in your situation.

This Manual has been planned and written for the purpose of making suggestions which might be helpful as you and your children work with *Experimenting in Science.* But since the ideas given in this Manual are purely suggestions, you should not feel that you are bound by them in any way.

With this in mind each chapter of the Manual has been organized on the following plan:

An Introduction
Science Meanings for Children
Information for the Teacher
Ways of Working with Children
Materials Needed
A Discussion of End-of-Chapter Activities
Further Activities
Evaluation
Bibliography
Films
Filmstrips

Introduction · The introduction gives a brief, thumbnail sketch of the chapter in as few words as possible.

Science Meanings for Children · In this section the various, important meanings which are developed in the chapter are picked out and enumerated for your inspection. As you glance at these meanings, you will have an indication of those concepts which the authors have felt were important and toward which the children might be guided in their conceptual growth. This listing may guide you in your planning, in the kinds of supplementary activity which you encourage children to have, as well as in your evaluation of the learning which has resulted from the study of the chapter.

The teacher and children are utilizing the natural environment near the school. The easy accessibility of this outdoor laboratory gives them an opportunity to test ideas and gather additional information.

Wahl-Coats Elementary School, Greenville, North Carolina. J. D. Henry

Information for the Teacher · This section is not intended to be a comprehensive coverage of the content or subject matter of the chapter. For a comprehensive treatment of the content included in each chapter one should refer to *Science for the Elementary-School Teacher* by Gerald S. Craig and to other sources listed in the bibliographies for the teacher in this Manual.

This section is intended to provide some additional material which you may find helpful. It also highlights and summarizes the content and some of the activities which are included in the chapter.

Important aspects of the content are also pinpointed and some of the implications of the content are discussed. Throughout there has been an attempt to be concise and to the point. This position has been adopted because it is recognized that elementary-school teachers are busy and it is important that their time not be wasted.

Ways of Working with Children · Specific suggestions are made for ways of stimulating interest and enhancing the value of the material for the children. These suggestions in relation to each chapter

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This type of activity requires the children to have a fundamental grasp of the ideas they are attempting to represent. Opportunity to represent ideas pictorially aids the children in refining and building more adequate conceptions.

concern experiments and demonstrations, observation, reading, field trips, utilizing resource people, and discussions.

These suggestions represent a very definite view of the teaching-learning process. This point of view is not one which is characterized by haste, but one which suggests that teachers and children relax. Do not hurry from one content item to another. Such hurry creates false pressure upon you and your children. It also tends to inhibit critical thinking. As much as possible, we should attempt to get in step with the natural tempo and rhythm of children.

Throughout the specific suggestions contained in this section there is the intent that opportunities be provided for the children to react to the learning through discussion, special reports, and interviews. These types of activity provide time for learning elements to be absorbed, to be thought over, and to become acceptable in a real sense. We might think of this process as "internalizing." That is, it is a process by which children take the learning, inspect it, turn it over in their minds, and consider it in relation to other material which they have already learned. A more detailed account of the need for such time and the process involved is contained in *The Development of Scientific Concepts in a Young Child: A Case Study* by John G. Navarra.[1]

You will also find that the specific suggestions contained in this section of each chapter encourage children to do original and creative thinking for themselves. There are, of course, degrees of critical thinking; but there are opportunities at all levels to improve. The thinking of children in the sixth grade is not as refined as the thinking of a scientist within his own area of specialization. But the thinking of eleven- and twelve-year-old children displays creative elements which can be reinforced, refined, and improved under the guidance of a skillful teacher.[2]

No single procedure is advocated as the best way of working with children. You will find that a variety of specific procedures are indicated. In some of the earlier chapters, attention is focused on ways of opening up the chapter with the children. This is not carried on through every succeeding chapter, since it is felt that as you test out some of these suggestions you will carry on those you find practical and acceptable in your situation. In each chapter of this Manual, the suggestions are varied and new suggestions are continually introduced. These provide an element of challenge throughout and also allow you to try out, select, and develop your own successful procedures.

Materials Needed · A list is included in each chapter to provide at a glance the minimum materials which the group will need to

[1]Navarra, John G., *The Development of Scientific Concepts in a Young Child: A Case Study* (Bureau of Publications, Columbia University, 1955).
[2]Hill, Katherine, *Children's Contributions in Science Discussions* (Bureau of Publications, Columbia University, 1937).

perform the experiments and demonstrations in the text. As you will note, these are common materials which usually can be secured from the local community. You may also find this list will help as you plan your methods, procedures, and additional activities.

End-of-Chapter Activities · Specific notes, suggestions, and references are made in relation to the section of activities for children found at the end of each chapter in *Experimenting in Science*. These notes immediately precede the section on Further Activities. They are designed to aid you as you work over the topics and activities included in this last section of each chapter of the text.

Further Activities · A variety of additional activities are suggested in each chapter of the Manual. They are designed to lead the children out into a further exploration of a particular topic. You should not feel that you are limited by these lists. Rather they offer suggestions which should stimulate the children to find additional topics for examination and study.

Evaluation · In this section you will find suggestions for evaluating the children's growth and behavior. Again it should be pointed out that the suggestions are varied. As you select your methods of working with children, you should also be considering the selection of your evaluation procedures. Evaluation is a process which goes hand in hand with the teaching-learning process. As you experiment with teaching procedures, you will also want to experiment with procedures of evaluation.

The final choice of procedures is up to you. You will find that some suggestions made in the earlier chapters as to evaluation procedures are not contained in later chapters. Other suggestions and techniques are developed in later chapters. As you work with your children, out of the variety of suggestions you may evolve and develop techniques which are particularly suited to you and your group. You should feel free to carry these procedures over from chapter to chapter.

Bibliography · Each list of further readings for the teacher should be of great help to you. These books should enable you to extend your background and refresh your understanding of the topic being

considered. For the most part, the books recommended are written in a simple, nontechnical style which makes for ease of reading.

Each book in each list for children has been examined as to its appropriateness to the topic as well as in relation to a reading level range usually found in this age group. There are variations in the reading level of any group, so some of the books may be more appropriate to one segment of your group and others more appropriate to another segment.

The lists of books included in this section of each chapter is not exhaustive. They are rather suggestive of some of the material which can be found in the field and which you may suggest to children. You should not feel bound or limited to these particular lists.

You will note that many books have received only one listing in this Manual. That is, a particular book may be listed under only one chapter. This is the chapter for which it is most appropriate. However, it may possibly be used with profit in connection with more than one chapter. You may also find that some of the books listed for children will be helpful to you as well. And in a few instances titles suggested in a bibliography for the teacher may prove of interest to certain of the children. This will best be determined by you and your children as they seek additional sources of information.

An important part of the learning undertaken by the children will be the seeking of additional, reliable sources of information for questions and topics which arise during the study of a particular chapter. The use of a library is an important part of the science experience. The sources will be most meaningful when the children themselves have sought them out in relation to a particular concern or purpose of their own. Children should also be encouraged to evaluate the reliability of the sources which they use for additional information.

Films and Filmstrips · These listings are also selective. They include those films and filmstrips which seem most appropriate to this level and to each particular chapter.

You may want to talk over the subjects with your children before deciding which films and filmstrips to choose. Although most of the listings are new, certain of the films have been listed in previous manuals in this series and may have already been viewed by

your children. This should in no way be a deterrent to you. It is often highly desirable and much may be gained by a subsequent review of a film or filmstrip, particularly when a new aspect of the learning is developed. You may, however, wish to slant your comments and queries slightly differently in cases of a second viewing by some or all of the children.

You may want to preview films and filmstrips before showing them to your group. The small amount of time consumed will be more than compensated for by the ease with which you will be able to handle queries. This will also help you to emphasize those portions of the sequences which are particularly suited to the aspect of the subject which concerns your group.

You should, of course, not feel bound by these lists. You will want to select your films and filmstrips in relation to specific purposes which you and your group of children set. There are many other films and filmstrips which you may feel are particularly appropriate during some phase of the topic which your children are investigating.

I

Energy Everywhere

Attention is focused in this chapter on the pervasiveness of energy. Energy is truly everywhere. Evidence of this energy is in the vast amount of movement which is taking place all around us. Air is moving; clouds are moving; birds are in flight; animals are moving across the surface of the earth; and we too are moving. The uses of energy are described through discussion of the various kinds of energy which the children meet in the normal course of living. There is a basic and challenging treatment of the sun as an energy source which is atomic in nature. The subject of fuels and their use to release energy is presented through simple demonstrations which are in the immediate experience of children. The concept of atomic energy is developed in a positive way as a further step in man's use of fuels to produce energy.

Science Meanings for Children

In *Energy Everywhere* children may be helped to gain an understanding of energy and the importance of energy in our lives. As children explore and discover for themselves new learnings in this area, it is hoped that they will become aware of the constant search of man for ways of using energy more effectively.

Each child will bring to this particular area of science many observations and experiences. The extent to which each individual gains new meanings as this area is explored and experienced will also differ. The following meanings may be helpful as a guide in using the materials in this chapter:

A change of any kind involves energy.

There are many forms of energy. Among these are chemical energy, electrical energy, mechanical energy, light, sound, and heat.

Long before man knew much about the sun, he was able to use its energy.

The energy of the sun is produced from atoms. We are still learning about the atomic energy of the sun.

Energy is released when we use a fuel properly.

Everything is made of small moving particles called atoms. The outer parts of an atom are called electrons.

Electrical energy is a movement of electrons.

There is energy stored in coal. This is sometimes called "stored sunlight."

Long before people lived on the earth, great bodies of water called bays covered most of North America. The plants which formed coal grew in the swamp forests of long ago.

Petroleum was probably formed from the remains of small animals and plants that were much like those we find in some shale and limestone today.

A number of other fuels, such as gasoline, kerosene, and diesel oil are made from the natural fuel called petroleum.

Wind is brought about mainly by gravity and the energy of the sun. Man has used and is learning to use the energy of wind power.

Man has learned how to benefit from the energy of moving water.

There are vast quantities of energy inside the atom.

One problem in the use of atomic energy is to release the energy so it can be used when needed to run machinery.

Uranium is one fuel which is being used to release atomic energy.

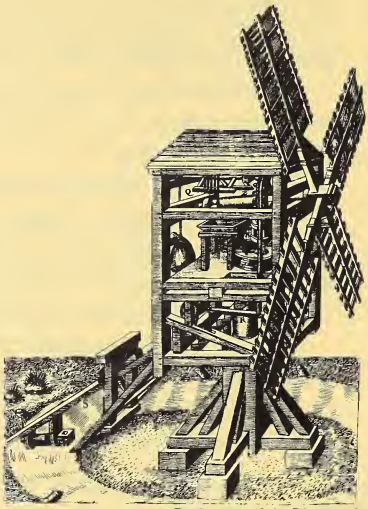
Information for the Teacher

On pages 5 and 6 of *Experimenting in Science* the concept is developed that everything moving, whether living or nonliving, involves the use of energy. This is developed principally around the idea that nothing moves without energy. Whenever an object moves, work is a result of that movement. To start an object moving, energy is needed to overcome the inertia of the object. Continued movement necessitates a continued expenditure of energy.

Energy is often described as the ability to do work. This definition has purposely not been included in the text, for it is felt that children may gain greater understanding of the meaning of the word through experiences and demonstrations than through a memorized definition. A change of any kind involves energy, and energy has many different forms. Those discussed in *Experimenting in Science*

are: heat, light, sound, electricity, mechanical energy, chemical energy, and atomic energy. In addition, radio waves and X rays are also considered to be forms of energy.

On pages 7 and 8 of *Experimenting in Science* the fact that a change of any kind involves energy is illustrated through a number of experiments and demonstrations. They have been selected for the ease with which the materials may be procured and for the challenge and interest they will arouse in the children.



By Courtesy of the Director of the Science Museum, London

A windmill for grinding corn—from an illustration published in Europe in 1588.

Man is constantly concerned with the different kinds of energy that help him do his work. Historically, man first used his own muscle energy to do work. Discovery followed discovery, and eventually man harnessed the muscle energy of animals to make his work easier. Man constantly searched for ways of doing his work more easily. He found that the energy of the wind could be used to sail boats. Wind was used to provide the energy for some of the first machines that were not driven by the energy of muscles. During the Middle Ages windmills were used to grind grain. In some places today the energy of the wind is used in pumping water or generating electricity. However, since wind changes in its intensity, it is not a very reliable source of power.

Wind energy is important in many ways. Wind moves the clouds over the earth's surface and distributes rain for crops, lakes, and rivers. The driving power behind the wind is really energy from the sun. The earth's surface is heated unequally. Air expands and becomes lighter when it is heated. Colder, heavier air pushes this lighter air up. This motion, coupled with the force of gravity, brings about the movement of air we call wind.

To understand energy in any form, it is helpful to relate it to a discussion of atoms and electrons. The earth and everything on it are believed to be composed of about one hundred basic substances, or chemical elements, in various combinations. The smallest particle into which an element can be divided and still retain the characteristics of that element is called an atom. Oxygen, hydrogen, silver, iron, copper, and calcium are a few familiar elements.

All atoms are atoms of elements. There is no such thing, for example, as an atom of glass. The atoms in glass are atoms of elements such as silicon, calcium, sodium, and oxygen of which the glass is made. These of course vary according to the kind of glass.

An individual atom is so small as to be invisible, even with the most powerful microscope. It is believed that all atoms are in constant motion and they all have basically the same structure. This consists of a central nucleus and a system of electrons moving in orbits. For the sake of simplicity, we might say that there are three basic particles: electrons, protons, and neutrons. Electrons are considered to be negative charges of electricity, and protons are considered to be positive charges of electricity. Neutrons are considered to be neutral. Neutrons are sometimes said to be made up of a proton and an electron in close association.

Protons and neutrons are considered to be in the nucleus of an atom. Electrons are believed to revolve around the nucleus in definite orbits. Atoms of various materials differ from one another only in the number of protons, neutrons, and electrons which make up the individual atoms.

Let it be clear, that the above information has been presented for your own understanding and not as information which you should teach directly to children.

A simple experiment may help in understanding the concept of atoms and elements. Obtain some copper sulfate from a drugstore or a scientific supply house. Place a quarter of a cup of copper sul-

fate in a tumbler of water. Stir the solution until most of the copper sulfate is dissolved. Some of the copper sulfate will not dissolve. The color of the water will now have become blue.

Copper sulfate is made up of three different kinds of atoms: copper atoms, sulfur atoms, and oxygen atoms. Of course we all know what the metal copper looks like. You have only to examine a copper penny to see the color and texture of copper. Sulfur is yellow in appearance and is often crushed and used in the form of a yellow powder. Small containers of sulfur powder may be purchased from a drugstore to get an idea of the texture and quality of sulfur. Oxygen is known best as an invisible gas which we breathe. It is, of course, in the air that surrounds us.

None of these atoms appear to be in the blue solution of copper sulfate, do they? But we can show that there actually are copper atoms in it. Take a clean iron nail and dip it in and out of the blue solution. As you do this, you will note that a copper color begins to coat the nail. The first visible sign of the copper color appearing on the nail means that millions of copper atoms have begun to accumulate on it. These atoms, which resemble a copper penny in

Invisible copper atoms in a solution of copper sulfate become visible when enough of them collect on an iron nail. Their distinctly copper color can clearly be seen.

color, were part of the solution of copper sulfate even though they could not be seen in it.

The chart on the following pages gives the names of the chemical elements, and the symbol, atomic number, and physical state of each.

The following information may help to make the chart meaningful: The symbols are derived from the first letter or the first letter and a second letter from the English or Latin names of the elements. In this way differentiation can be made between the symbols of elements whose names begin with the same letter. For example, the symbol for sulfur, S, is derived from the first letter of its English name, but the symbol for sodium, Na, comes from the Latin name for sodium: natrium. Let's take a look at carbon, chlorine, and copper. The symbol for carbon is the first letter of its English name: C. The symbol for chlorine is the first and third letters of its English name: Cl. However, the symbol for copper is Cu. This is derived from the Latin name for copper, which is cuprum.

The atomic number indicates the number of protons contained in the nucleus of each atom of each element. Since atoms are believed to have customarily the same number of protons as electrons, the atomic number indicates also the number of electrons in each atom. The latter information might be of particular interest when you are working with the chapters in the text dealing with atoms and electrons in relation to light energy and to magnetism. (See pages 126–130, 202–203 of *Experimenting in Science* and pages 83–84 and 122–124 of this Manual.) The physical states listed in the chart describe the state of each element under ordinary atmospheric conditions. It may be of interest to note that only two elements, bromine and mercury, are customarily liquid.

On pages 10, 11, 12, and 13 of *Experimenting in Science* electricity is described in detail as a form of energy which does much work for us. It is changed into heat energy when we use a toaster, an iron, or an electric stove. It is changed into light energy when we use an electric light. A current of electricity is rather hard to define. However, the opinion of most scientists would indicate that it is a movement of electrons. These electrons are considered to be free; that is, they are electrons which have become separated from the outer orbits of atoms. Electrical energy runs motors, rings bells, and supplies us with light at night when the light energy from the sun is not available to us.

Just as electrical energy can be changed into heat, light, sound, and mechanical energy, so can other forms of energy be changed into electrical energy. Falling water, burning coal, or wind may be used to produce electrical energy. Electricity may also be produced from the action of certain chemicals, as in a dry cell or a storage battery when wires are connected to form a circuit.

On pages 14 and 15 of *Experimenting in Science* the principle of the sun's energy is discussed. This section deals briefly with the fact that the sun is made of millions of atoms. As these atoms combine, much energy is released; so the energy of the sun is really atomic energy. On pages 15–21 the concept is developed that coal

CHART 1 · THE CHEMICAL ELEMENTS*

Element	Symbol	Atomic number	Physical state	Element	Symbol	Atomic number	Physical state
hydrogen	H	1	gas	cobalt	Co	27	solid
helium	He	2	gas	nickel	Ni	28	solid
lithium	Li	3	solid	copper	Cu	29	solid
beryllium	Be	4	solid	zinc	Zn	30	solid
boron	B	5	solid	gallium	Ga	31	solid
carbon	C	6	solid	germanium	Ge	32	solid
nitrogen	N	7	gas	arsenic	As	33	solid
oxygen	O	8	gas	selenium	Se	34	solid
fluorine	F	9	gas	bromine	Br	35	liquid
neon	Ne	10	gas	krypton	Kr	36	gas
sodium	Na	11	solid	rubidium	Rb	37	solid
magnesium	Mg	12	solid	strontium	Sr	38	solid
aluminum	Al	13	solid	yttrium	Y	39	solid
silicon	Si	14	solid	zirconium	Zr	40	solid
phosphorus	P	15	solid	niobium	Nb	41	solid
sulfur	S	16	solid	molybdenum	Mo	42	solid
chlorine	Cl	17	gas	technetium	Tc	43	solid
argon	A	18	gas	ruthenium	Ru	44	solid
potassium	K	19	solid	rhodium	Rh	45	solid
calcium	Ca	20	solid	palladium	Pd	46	solid
scandium	Sc	21	solid	silver	Ag	47	solid
titanium	Ti	22	solid	cadmium	Cd	48	solid
vanadium	V	23	solid	indium	In	49	solid
chromium	Cr	24	solid	tin	Sn	50	solid
manganese	Mn	25	solid	antimony	Sb	51	solid
iron	Fe	26	solid	tellurium	Te	52	solid

*This chart is presented as background material for you. It is not intended that the material in it be taught to your children. The chart may be useful as you help children find answers to questions that arise concerning atoms and electrons.

CHART 1 · THE CHEMICAL ELEMENTS* (*Continued*)

Element	Symbol	Atomic number	Physical state	Element	Symbol	Atomic number	Physical state
iodine	I	53	solid	platinum	Pt	78	solid
xenon	Xe	54	gas	gold	Au	79	solid
cesium	Cs	55	solid	mercury	Hg	80	liquid
barium	Ba	56	solid	thallium	Tl	81	solid
lanthanum	La	57	solid	lead	Pb	82	solid
cerium	Ce	58	solid	bismuth	Bi	83	solid
praseodymium	Pr	59	solid	polonium	Po	84	solid
neodymium	Nd	60	solid	astatine	At	85	solid
promethium	Pm	61	solid	radon	Rn	86	gas
samarium	Sm	62	solid	francium	Fr	87	solid
europium	Eu	63	solid	radium	Ra	88	solid
gadolinium	Gd	64	solid	actinium	Ac	89	solid
terbium	Tb	65	solid	thorium	Th	90	solid
dysprosium	Dy	66	solid	protactinium	Pa	91	solid
holmium	Ho	67	solid	uranium	U	92	solid
erbium	Er	68	solid	neptunium	Np	93	solid
thulium	Tm	69	solid	plutonium	Pu	94	solid
ytterbium	Yb	70	solid	americium	Am	95	solid
lutetium	Lu	71	solid	curium	Cm	96	solid
hafnium	Hf	72	solid	berkelium	Bk	97	solid
tantalum	Ta	73	solid	californium	Cf	98	solid
tungsten	W	74	solid	einsteinium	E	99	solid
rhenium	Re	75	solid	fermium	Fm	100	solid
osmium	Os	76	solid	mendelevium	Md	101	solid
iridium	Ir	77	solid	nobelium	No	102	solid

*This chart is presented as background material for you. It is not intended that the material in it be taught to your children. The chart may be useful as you help children find answers to questions that arise concerning atoms and electrons.

and petroleum are fuels through which we utilize the sun's energy of long ago. Coal was formed many millions of years ago. At that time huge trees and other plant life grew in great abundance. Green plants utilized the sun's energy to produce plant food and to grow. As time passed, these plants fell into the swamps in which they were growing. The chemical process of decay and the mechanical folding of the rocks which surrounded the coal beds gradually changed these plant remains into the coal we use today. On pages 19, 20, and 21 of *Experimenting in Science*, the formation of petroleum, its dependence on the sun's energy, and the method of recovery from the rock structures in which it is trapped are discussed.

The energy of petroleum has been of ever-growing, world-wide importance in the past few years. The chart on page 19 indi-

cates how world production of petroleum has been increasing. Perhaps advances in our knowledge of atomic energy will eventually bring about a reversal of this trend. But at the present time our civilization depends to a large extent on the energy from petroleum and petroleum products.

Energy from the sun is the basis of many of the energy sources which man utilizes. Water power is among these energy sources dependent on energy from the sun. This concept is developed extensively on pages 23–24 of *Experimenting in Science.* Man has learned to use the energy of falling water to replace muscle energy.

The section on atomic energy on pages 25 and 26 of *Experimenting in Science,* although brief at this point, is very important. The manner of its presentation relies upon the previous development of fuels contained in the earlier sections of this chapter. The concept developed is that atomic energy is a part of man's larger and long-range concern with energy and energy sources.

You will find much interest in this subject on the part of your children and a desire for further information. This section of the Manual should provide useful background material for you, although it is not necessary or even desirable to include it in all your teaching. Further material on atoms and electrons will be found in *Experimenting in Science* on pages 126, 132–133, and 202–203, and in the Manual on pages 83–84 and 122–124. The book lists at the end of this chapter will be of assistance in providing still more material for both you and your children.

Ways of Working with Children

Since energy is a theme which runs through the succeeding chapters of *Experimenting in Science,* it is suggested that the meanings presented in *Energy Everywhere* be developed early in the school year.

You may want to introduce the study of energy by taking your group out into the schoolyard to observe different kinds of movement. In a city, children may see paper being carried by the wind, busses and cars moving along the street, a policeman signaling traffic to move on, a semaphore changing from red to green, people walking, clouds floating in the sky, an airplane flying overhead.

Children in the country may see a truck moving down the road,

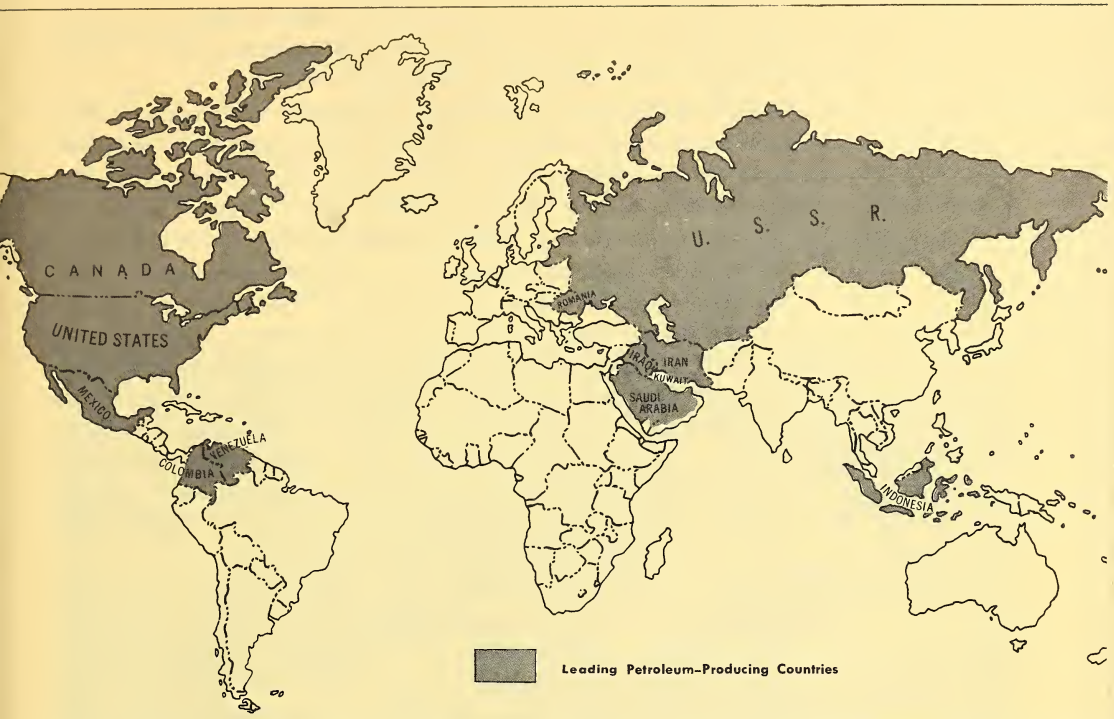


CHART 2 · WORLD PRODUCTION OF CRUDE PETROLEUM IN MILLIONS OF BARRELS (42 GALLONS EACH)*

Year	Canada	Colombia	Iran (Persia)	Iraq	Kuwait	Mexico	Indonesia	Romania	U.S.S.R.	Saudi Arabia	United States	Venezuela	World Totals
1949	21.4	29.7	204.7	31.0	90.0	60.9	43.2	33.7	237.7	174.0	1,841.9	482.3	3,404.1
1950	29.0	34.1	242.5	49.7	125.7	72.4	48.4	32.0	266.2	199.5	1,973.6	546.8	3,803.0
1951	47.6	38.4	127.6	65.1	204.9	77.3	55.5	31.0	285.0	278.0	2,247.7	622.2	4,286.0
1952	61.2	38.7	10.1	141.1	273.4	77.3	62.5	45.0	322.4	301.9	2,289.8	660.3	4,509.9
1953	80.9	40.2	9.4	210.3	314.6	72.4	75.1	52.0	363.0	308.3	2,357.1	644.2	4,770.8
1954†	96.0	40.5	22.4	228.4	347.3	83.7	79.4	55.0	411.0	347.8	2,315.0	691.8	4,990.8
1955†	129.5	40.0	100.0	245.0	400.0	90.0	87.0	60.0	420.0	350.0	2,484.5	780.0	5,300.0

*This chart is presented as background material for you. It is not intended that the material in it be taught to your children. The chart may be useful as you help children find answers to questions that arise concerning fuels.

†Estimate.

cattle grazing in a nearby pasture, a farmer harvesting his crop. Some signs of movement will, of course, be observed by children no matter what environment they may be living in.

Instead of going out-of-doors, children may make some of these same observations from the windows of the classroom. It is helpful to have the children make a list of their observations. This first experience is to help the group become aware of the many things around them that move. This will tie in with speculation introduced in the book concerning what energy is. These observations and the discussion concerning them can also help to clarify the fact that we see what energy does, but we cannot see the energy.

Perhaps when you and your group are out-of-doors, you will hear the sound of a siren or a factory whistle. During the discussion you may wish to propose such questions as, "Did you hear the factory whistle?" "Do you think there was any movement involved when we heard the whistle?" "What kind do you think it was?" "What kind of energy was used?" Encourage children to express their ideas or form hypotheses.

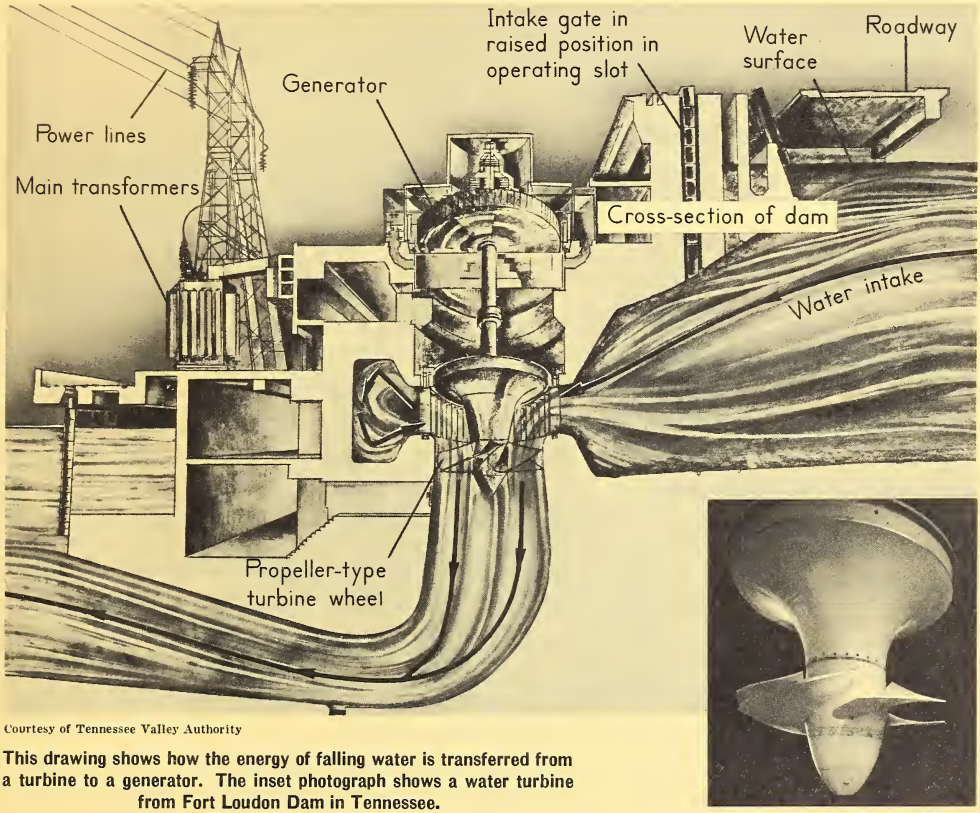
At this point in the discussion, you may wish to introduce and consider the illustration on pages 4 and 5 of *Experimenting in Science*. It serves to bring out other examples of movement, some of which the children may not have observed in their environment. As children discuss the various examples of movement in the illustration, they may want to compare them with the list of observations they have made.

The other illustrations in this chapter may also serve to broaden children's understanding, to motivate discussions, and to clarify concepts of energy. Some of the illustrations, such as that on page 7 of *Experimenting in Science*, suggest experiments which a child or a small group of children may do for the class. The printed material on that page also will help the child or group in doing the experiment in preparation for discussion with the class. Still other illustrations, such as the one on page 12 of *Experimenting in Science*, suggest other experiments children may do in the classroom.

Children usually like to repeat experiments. This repetition can be directed and used to develop the understanding that one's observations and conclusions must be checked carefully against the experiments, observations, and conclusions of others. It is the intention of the authors that the experiment with chemical energy on

page 7 of *Experimenting in Science,* examining a new and old dry cell described on page 12, as well as others throughout the chapter, be done by individual children. Children learn through reading and discussing. They also learn by seeing, feeling, and manipulating.

You may wish to emphasize the up-to-date aspect of the material in this chapter by relating it to historical developments of the past. For instance, at first man used the energy of falling water to push a paddle wheel. The water moved the wheel and this resulted in work being done. Today the principle of the old-fashioned mill wheel is made use of in huge water turbines to generate electricity.



Courtesy of Tennessee Valley Authority

This drawing shows how the energy of falling water is transferred from a turbine to a generator. The inset photograph shows a water turbine from Fort Loudon Dam in Tennessee.

Recording information may help children in organizing their ideas. Reporting the results of an experiment done, making diagrammatic charts, making lists, are kinds of recording activities which you may encourage children to undertake.

Additional suggestions for various ways of working with children are contained in the section *Learning More About Energy* below. These suggestions are made in relation to specific activities, but they can carry over to other facets of the work when you think they are applicable.

Materials Needed

baking soda
bulb, flashlight
chisel
clay, papier maché, or Plasticine
dry cells, 1 new and 1 old No. 6
hammer
knife
lemon juice
measuring cup
measuring spoons
sand
socket, for flashlight bulb
thermometer, outdoor
tin can, with cover
tumbler
water
wire, insulated copper and iron

Learning More about Energy

See suggestions for children, page 27, *Experimenting in Science.*

1. A committee of children may wish to make a chart showing the different ways electricity is used. They may want to illustrate the chart with their own drawings or pictures cut from old magazines. Have the committee share their chart with others in the group. Instead of a chart, the committee may want to record their findings in the form of a bulletin-board display.

2. In writing a story, children may draw on some of their own observations and experiences. Some children may want to do a certain amount of research in the school or public library to get information that will help in writing the story. Have children read their stories to others.

3. The lists of fuels made by individuals might be extended and made into pictorial charts showing how each fuel is used in order to release energy from it.

4. Helping children become aware of the big sources of energy for their community may develop into a trip into the community where children may learn more about energy. A map showing where these energy sources are may help the group become more aware of their community.

5. Some children may wish to show the development of methods of transportation pictorially or by the use of models. There are usually individuals within a group who are stimulated to go beyond the learnings of others in the group.

6. In finding such information, you may help children in exploring the resources of the library. Some of the books listed at the end of this chapter may also be useful. Magazine articles also appear from time to time which have information that some children may find stimulating. Children may also want to check on the authenticity of the material found in magazines.

Further Activities

1. Have a committee make a report on the products of coal or petroleum. They may want to bring samples of some of these products and make a display.

2. Have the children make pictorial charts showing the different kinds of energy changes. For example, one chart may be labeled "Electrical Energy." A picture of a toaster may have a caption under it, such as "A toaster changes electrical energy to heat energy." A picture showing an electric stove may have a similar caption under it, and so on. Make similar charts for other kinds of energy.

3. A model of clay or papier-maché may be made showing layers of coal. The text and diagram on page 19 of *Experimenting in Science* will be helpful. Labels should be carefully made.

4. Have the children make a model of clay, papier-maché, or Plasticine showing how petroleum is trapped in the ground. Label the various layers. The diagram and text on page 21 of *Experimenting in Science* will be helpful.

5. This is an experiment that shows energy change: Get a tin can that has a cover. Fill the can about half full of sand. Put a

thermometer in the sand and record the temperature. Remove the thermometer, cover the can, and shake it about a hundred times. Again take the temperature of the sand. The mechanical energy which you used to shake the can produces a rise in temperature in the sand.

Evaluation

"What evidences of growth in terms of planning, discussing, evaluating did I see among my group today? Have the children enjoyed what we did? Did some children participate who have not ordinarily done so?" These or similar questions may be ones which you ask yourself as you evaluate the progress of children in science. Evaluation is part of the teaching process. It helps you as you do your daily planning. It helps your boys and girls and you as you plan together. Evaluation is done in terms of the purposes set by you and your group. The following suggestions may be helpful as you consider ways of evaluating children's experiences in this area of science.

1. Have children as a group summarize the important learnings from this study of energy. This will give them an opportunity to clarify and organize ideas.

2. Have children evaluate their ways of working. This evaluation might be conducted as a discussion by the whole group of children. The following questions are a sampling of the type which you might suggest to aid the children in their evaluation: Did each child contribute to the planning? Was a variety of sources used in gathering information? Did the various committees assume responsibility for getting materials in doing the experiments?

3. The children may wish to invite another group in to see their charts, models, and drawings, thereby bringing out important learnings.

4. How have the children's concepts of fuel been altered or enlarged? In what ways have they attempted to relate the traditional concept of fuel with the concept of the zinc of a dry cell as fuel or their concept of atomic fuel?

5. Through the drawings, models, and the charts made by children, the teacher can evaluate the learnings of children gained through reading, discussing, listening, and observing.

Bibliography

For the Teacher

Beeler, Nelson F., and Branley, Franklyn M. *Experiments with Atomics.* Thomas Y. Crowell Company, 1954.

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It*, Chapters 6, 7, 19. The Dryden Press, 1951.

Burnett, R. Will. *Teaching Science in the Elementary School*, Chapters 10 and 11. Rinehart & Company, Inc., 1953.

Craig, Gerald S. *Science for the Elementary-School Teacher*, Chapters VII, XIX, XX, and XXI. Ginn and Company, 1947.

Hecht, Selig. *Explaining the Atom, Revised Edition.* The Viking Press, 1954.

Rowland, John. *Atoms Work Like This.* Roy Publishers, 1956.

For the Children

Adler, Irving. *Fire in Your Life.* The John Day Company, 1955.

Baer, Marion E. *Sound: An Experiment Book.* Holiday House, 1952.

Barrow, George. *Your World in Motion: The Story of Energy.* Harcourt, Brace and Company, 1956.

Beeler, Nelson F., and Branley, Franklyn M. *Experiments in Chemistry.* Thomas Y. Crowell Company, 1952.

Bischof, George P. *Atoms at Work.* Harcourt, Brace and Company, 1951.

Floherty, John J. *Flowing Gold: The Romance of Oil.* J. B. Lippincott Company, 1945.

Freeman, Ira Maximilian. *All about the Wonders of Chemistry.* Random House, Inc., 1954.

Geralton, James. *The Story of Sound.* Harcourt, Brace and Company, 1948.

Hyde, Margaret O. *Atoms Today and Tomorrow.* McGraw-Hill Book Company, Inc., 1955.

Meyer, Jerome Sydney. *Picture Book of Electricity.* Lothrop, Lee & Shepard Company, Inc., 1952.

Potter, Robert Ducharme. *Young People's Book of Atomic Energy.* Dodd, Mead & Company, Inc., 1952.

Ravielli, Anthony. *Wonders of the Human Body.* The Viking Press, 1954.

Schneider, Herman and Nina. *More Power to You.* William R. Scott, Inc., 1953.

Schneider, Herman and Nina. *Rocks, Rivers and the Changing Earth.* William R. Scott, Inc., 1952.

Williams, Henry L. *Stories in Rocks.* Henry Holt and Company, Inc., 1948.

Films

ATOM GOES TO SEA. (GE) 1 reel, b/w; free. Describes how an atomic-powered submarine goes to work.

ATOM SMASHERS. (EBF) 1 reel, b/w. Describes how scientists are developing machines and techniques for the production and use of nuclear radiations.

FOSSIL STORY. (Shell) 1½ reels, color; free. Pictures types of fossils, shows how they are used to learn about life in prehistoric times, as well as their value to the oil industry in its search for new resources.

HOW WE GET OUR POWER. (YAF) 1 reel, b/w. Explains how all our power comes from nature—from wind, water, fuels, explosives, and the atom.

LEARNING ABOUT ELECTRIC CURRENT. (EBF) 1 reel, b/w. Explains an electric circuit. Shows use of resistance materials to cause heat and light, and the use of electric current to make a magnet.

LEARNING ABOUT HEAT. (EBF) 1 reel, b/w. Demonstrates by animation and live action the properties and characteristics of heat. Shows its effect on matter and how it travels by conduction, convection, and radiation.

LEARNING ABOUT SOUND. (EBF) 1 reel, b/w. Explains what sound is, how sound travels, and how it is heard. Shows three common methods of producing sound.

MAKING ELECTRICITY. (EBF) 1 reel, b/w. Explains how a small, hand-powered generator may be constructed and operated. Shows how, by the same principles, a large hydroelectric power plant produces and distributes electricity.

OUR COMMON FUELS. (Cor) 1 reel, b/w & color. Shows how natural and manufactured fuels are obtained, and stresses their importance and the need for fuel conservation.

SOLIDS, LIQUIDS, AND GASES. (YAF) 1 reel, b/w. Demonstrates how a substance can be changed from one state of matter to another, depending on the application of heat or cold.

SOUNDS ALL ABOUT US. (Cor) 1 reel, b/w. Demonstrates that sounds are caused by vibrations or movement of objects. Illustrates that sounds can differ in pitch, in loudness, and in quality.

THE STORY OF COAL. (KB) 1 reel, b/w. Pictures how coal is formed and how it is used.

THE STORY OF OIL. (YAF) 1 reel, b/w. Shows how an oil field is located, how an oil well is drilled and how crude oil is stored before being pumped to refineries.

WATER WORKS FOR US. (YAF) 1 reel, b/w. Illustrates the many ways in which water works for us in our everyday life.

WHAT IS SOUND? (YAF) 1 reel, b/w. Discusses the nature, source, and transmission of sound waves.

WINDS AND THEIR CAUSES. (Cor) 1 reel, b/w & color. Illustrates and explains the winds of the earth.

Filmstrips

ALL MATTER HAS THREE FORMS. (YAF) b/w.

HOW WATER POWER PRODUCES ELECTRICITY. (PDP) b/w.

WATER AND ITS WORK. (YAF) b/w.

WHY DOES THE WIND BLOW? (SVE) b/w.

WIND. (FH) b/w.

THE WONDER OF ELECTRICITY. (EGF) color.

II

Why the Seasons Change

A comparative look at three sections of the globe during the same month of the year raises the questions: Why does the Southern Hemisphere warm up during the same months of the year that the Northern Hemisphere cools off? Why are there no seasons of spring, summer, fall, and winter at the equator? An understanding of the regular progression of the seasons in the two hemispheres is developed through the concepts of the tilted earth, the movement of the earth around the sun, and the way beams of sunlight spread out over this tilted earth. A series of unique experiments and demonstrations give the children a basis for interpreting the changes they observe as summer, fall, winter, and spring follow each other in a yearly cycle.

Science Meanings for Children

Many of the science meanings developed in this chapter will become a part of each child's understanding as he performs the experiments and demonstrations suggested in the text. Each child in your group will be able to make some of these meanings a part of his thinking. Do not feel disappointed if some children do not immediately grasp each of the meanings developed. Through discussion, repetition of experiences, and time for internalizing and thinking things over, each child will add to and enlarge the concepts with which he operates and is familiar. These are some of the science meanings developed in this chapter:

All places on earth have some sort of seasonal change.

The seasons in the Northern and Southern Hemispheres are just reversed. When it is autumn in the Northern Hemisphere, it is spring in the Southern Hemisphere.

The sun is always shining on the earth.

The earth rotates on its axis once each twenty-four hours, causing day and night. Half the earth is always turned toward the sun. Half is in shadow.

As the earth rotates it also moves around the sun. It takes our spinning earth approximately $365\frac{1}{4}$ days to make a complete revolution.

When light energy from the sun strikes the surface of the earth, it changes to heat energy.

Light energy from the sun produces different amounts of heat energy in different parts of the earth.

The amount of surface the sunlight spreads over affects the temperature of that surface. When light covers a small space, the heat of the area increases. When the same amount of light spreads over a larger area, the heat spreads out, too, resulting in lower temperatures.

The amount of surface that is lighted and heated changes as the surface tilts. Because the earth tilts, various parts of the earth change their positions in relation to the sun.

There are more hours of sunlight in summer than in winter.

The northern end of the earth's axis points in the direction of the North Star.

The way sunlight strikes our tilted earth is one reason for seasonal change.

As our spinning earth moves around the sun, the seasons on the earth change.

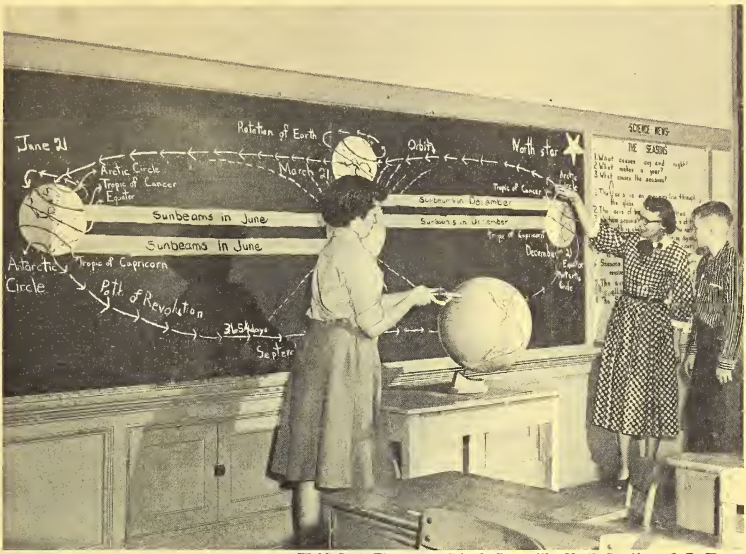
Information for the Teacher

When it is winter in the Northern Hemisphere, it is summer in the Southern Hemisphere. When it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere. The seasons in the Northern and Southern Hemispheres are just reversed. If distance from the sun were the cause of seasonal changes. we should be having summer all over the earth when the sun is closest to the earth and winter when the sun is farthest from the earth. However, this is not so. Actually the earth is closest to the sun during the month of December. But in this month the Northern Hemisphere is having winter and the Southern Hemisphere is having summer.

Seasonal change depends on other conditions than the earth's distance from the sun. The axis of the earth tilts at an angle of about $23\frac{1}{2}$ degrees away from a line from the sun perpendicular to the plane of the earth's orbit around the sun, as you see in the diagram in the

photograph below. Because the earth tilts, the sun's beams strike the earth more-or-less perpendicularly in the areas around the equator during the entire year. Light energy from the sun changes to heat energy when it strikes the earth's surface. The more vertical beams of sunlight produce high temperatures at sea level in the equatorial regions most of the year.

It helps us to express our ideas pictorially. Sometimes we have to discuss how pictures fall short of the actual relationships.



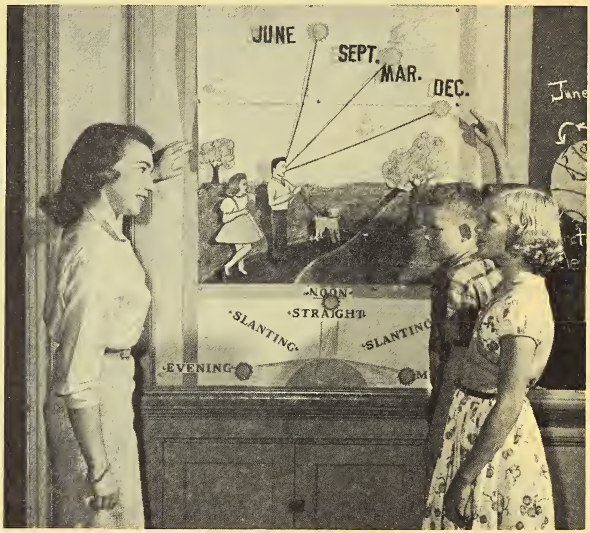
Wahl-Coats Elementary School, Greenville, North Carolina. J. D. Henry

The sun's beams fall more and more vertically over surfaces in the Northern Hemisphere during April, May, and June. On June 21 or 22 the vertical beams of the sun reach their most northern point at the Tropic of Cancer. During May, June, and July, the Northern Hemisphere receives more light and heat energy than at any other time of the year. At this time the sun's beams strike the area around the north pole. In June the sun never sets or rises in the Arctic Circle. The sun appears to move in a continuous circle above the horizon. The part of Norway which lies in this area is called "The Land of the Midnight Sun."

From the north polar regions, where there are 24 hours of sunlight each day in June, south to the equator the hours of sunlight gradually diminish. As we move south of the equator, the days grow shorter and shorter at this time of the year. At the south pole the

earth receives little or no light or heat energy from the sun for 24 hours a day in June. The night is said to be 24 hours long.

During August and September as the spinning earth continues on its path around the sun, the light begins to decrease at the north pole and to increase at the south pole. At the same time the days are growing shorter in the Northern Hemisphere and longer in the Southern Hemisphere. The beams of the sun continue to strike the equator more or less perpendicularly as they do throughout the year. On



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Many good discussions arise as the children compare their two-dimensional representation with the actual relationships which exist in space.

September 22 or 23 there are approximately 12 hours of sunlight during the day everywhere on earth. This is the autumnal equinox. Day and night are of equal length. There is light from pole to pole.

During October, November, and December, as the earth continues onward in its orbit, sunlight falls more and more vertically on the Southern Hemisphere. On December 21 or 22 the vertical beams of the sun fall on the Tropic of Capricorn. During November, December, and January, the Southern Hemisphere receives a greater amount of light and heat energy from the sun than at any other time of the year. The regions within the Antarctic Circle have daylight for 24 hours each day in December. Now Antarctica is the

land of the midnight sun while the north polar regions are having continual darkness.

During January, February, and March as the earth moves on in its orbit, the days are lengthening in the Northern Hemisphere and shortening in the Southern Hemisphere. On March 21 or 22, the spring or vernal equinox, days and nights are again of equal length everywhere on the earth. In the Southern Hemisphere it is the beginning of autumn; in the Northern Hemisphere it is the beginning of spring.

The seasons change because the earth is tilted on its axis and moves around the sun. When the Northern Hemisphere is having winter, spring, summer, and autumn, the Southern Hemisphere is having the opposite seasons,—summer, autumn, winter, and spring.

Ways of Working with Children

This chapter need not necessarily follow the first chapter, *Energy Everywhere*. However, those concepts relating to energy in connection with light, heat, and seasonal change will have more meaning when built on the general concept of energy developed in the first chapter. In the autumn children living in most parts of the Northern Hemisphere will notice that the number of hours of sunlight are growing less, and the air is growing cooler. They see changes in the plants and animals found in their environment.

Have children tell what September is like where they live. If some children have lived in other places, have them relate what September was like there. You may wish to make a list of their statements to point up any likenesses or differences in September. On a map of the world have children locate the places they mentioned. Are they all located in the Northern Hemisphere? Are some of the places near the equator? Are some of the places in the Southern Hemisphere?

At this point you may wish to introduce the group to the illustrations on pages 28 and 29 of *Experimenting in Science*. Locate Omaha, Belém, and Buenos Aires on a world map or globe. In what hemispheres are these places located? Discuss with the children what the text says about September in these three places. How does September there compare with September where they live? What makes these differences? Encourage children to give their ideas of why the

Southern Hemisphere warms up during the same months of the year that the Northern Hemisphere cools off. Help the group recall from their experiences in connection with the first chapter that both light and heat energy come from the sun.

Most of the learnings from this chapter will be gained by having children do the experiments and demonstrations before the group. Children like to experiment. Some experiments, like the one described on page 31 of *Experimenting in Science*, may be done by an individual for the rest of the group. You will want to provide time, however, in your program for the others in the group to repeat the experiments and demonstrations given before the entire group. Much learning is gained by each individual as he works through an experiment or demonstration.

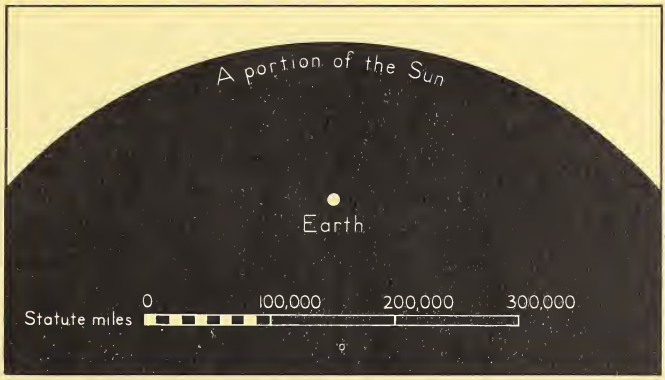
At other times a committee may work out an experiment and present it to the remainder of the group. The experiment on page 34 of *Experimenting in Science*, showing how light heats a small space, and the one on pages 36 and 37, showing how light spreads out on tilted surfaces, might be done by two different committees.

Throughout this chapter, *Why the Seasons Change*, the illustrations as well as the text will be useful in helping children to get the materials they need and follow directions for doing the experiments and demonstrations.

Helping children to summarize their findings for a particular problem is an important element of the teaching process. It would be well for children to summarize what they have learned in connection with one problem before going on to another. For example, after doing the experiments and verifying their observations through reading in connection with the problem, "How sunlight strikes the earth," the children may want to make summary sentences much like those listed on page 37 of *Experimenting in Science*. The sentences children give may be recorded on a chart for reference at a later time.

As children do the experiments and demonstrations, it is important that you relate their observation to the real sun and the real earth and seasonal change. An individual or a committee under your guidance might do the demonstrations of the movement of the earth around the sun suggested on pages 41–50 of *Experimenting in Science*. Help the children see that the light used to represent the real sun is much too small in comparison to the globe that represents

the earth. Our sun is a million times larger than our earth. It would be impossible to get a light large enough to be in correct proportion to the size of the globe. The relative distance between the globe representing the earth and the light representing the sun is also not accurate. To show that distance, if your globe is sixteen inches in diameter, the sun would need to be about thirty-two miles away. It is also important to bring out that as the earth moves around the sun, it is spinning on its axis. The sun, too, is not stationary, but moves through space as the earth rotates and revolves around the sun.



This diagram gives an idea of the relative sizes of the earth and sun in correct proportion.

In doing the demonstrations on pages 41–50 of *Experimenting in Science,* have the children check the illustrations to see whether they have set their demonstration up correctly. Encourage children to check their observations with those discussed in the text.

Allow plenty of time to do the demonstrations. They may take several days. You will want to have children move around during the demonstrations so that they can see how the light falls on the globe of the earth in different positions. If you allow plenty of time for children to observe and ask questions, you will be able to detect points of confusion and to clarify them. You will want to repeat the demonstrations several times. Vary them by having a child demonstrate why Buenos Aires has its winter season in June and July. Or demonstrate the season Buenos Aires is having when we are having our summer vacation.

Preparing a chart similar to the one suggested on page 45 of *Ex-*

perimenting in Science will be most helpful as your children make their observations. When they have finished their records, they will want to check them with those given in the text. The following is a completion of the chart shown on page 45 of the text.

	Sept. 23	Dec. 22	Mar. 21	June 22
Arctic Circle	12	0	12	24
Tropic of Cancer	12	10	12	14
Equator	12	12	12	12
Tropic of Capricorn	12	14	12	10
Antarctic	12	24	12	0

You may want to put the globe and light on a table at the side or back of the room for several days and give children the opportunity to repeat the demonstrations, count the lighted clay balls, and check their record. If each child can work through the demonstrations, he will have a better understanding of the reasons for seasonal change.

Materials Needed

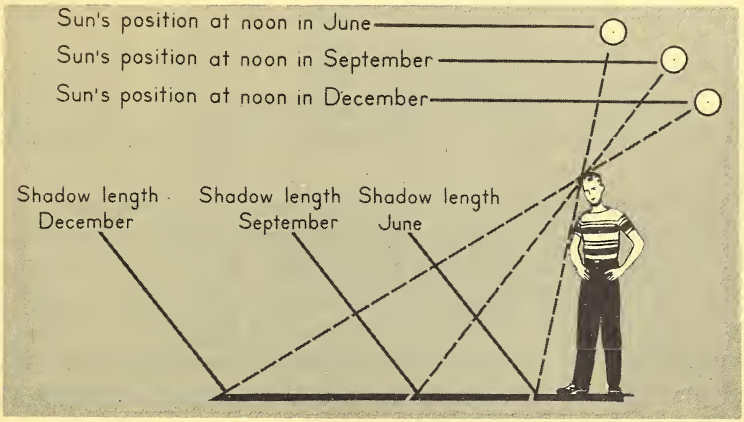
cardboard, including 3 pieces 12 inches square
clay or Plasticine
common pins
crayons
electric light
flashlight
globe, on a stand
magnifying glass
map of Western Hemisphere
paper, piece of, rolled into a tube
scissors
shoe boxes, 2
soil
tennis ball
thermometers, 2 outdoor
toothpicks

Learning More about Seasons

See suggestions for children, p. 51, *Experimenting in Science.*

1. You might guide children in grouping their activities as to games we play in different seasons, the clothing we wear, the food we eat.

2. During the day the children's shadows will be the shortest at twelve o'clock noon when the sun appears overhead. A month later the relative length of the shadows will depend on whether days are growing longer or shorter. In September, October, and November the shadows are lengthening. On December 22 in the Northern Hemisphere, the shadows are the longest they will be at noon for the year. After that date they gradually shorten. On June 22 the shadows at noon are extremely short, for on this date the sun's beams strike the Northern Hemisphere more perpendicularly than at any other time of year.


Sun's position at noon in June
Sun's position at noon in September
Sun's position at noon in December
Shadow length December
Shadow length September
Shadow length June

3. Some children may want to keep their record in the form of a chart. The chart shown on the next page is a sample only. The figures of course will vary depending upon your location and the season of the year. Those shown on page 36 are for New York City in October. Such a record of sunrise and sunset in your community will help children notice whether the hours of sunlight are increasing or decreasing according to the particular season approaching. Guide children to reread the text to help them get the answers to the two questions. They may wish to use the globe of the earth with the clay balls on it to help them arrive at an explanation for the relationship between a particular season and changes in the length of day.

4. Children may want to use the globe of the earth and a light in demonstrating their explanation of the rotation of the earth.

LENGTH OF DAY IN NEW YORK CITY IN AUTUMN

Date	Time of sunrise A. M.	Time of sunset P. M.	Number of hours and minutes of daylight	Increase or decrease in number of minutes of daylight
Oct. 1	5:56	5:43	11 h. 47 m.	
Oct. 2	5:57	5:41	11 h. 44 m.	− 3
Oct. 3	5:58	5:39	11 h. 41 m.	− 3
Oct. 4	5:59	5:38	11 h. 39 m.	− 2
Oct. 5	6:00	5:36	11 h. 36 m.	− 3
Oct. 6	6:01	5:34	11 h. 33 m.	− 3
Oct. 7	6:02	5:33	11 h. 31 m.	− 2
Oct. 8	6:04	5:31	11 h. 27 m.	− 4
Oct. 9	6:05	5:29	11 h. 24 m.	− 3
Oct. 10	6:06	5:28	11 h. 22 m.	− 2
Oct. 11	6:07	5:26	11 h. 19 m.	− 3
Oct. 12	6:08	5:25	11 h. 17 m.	− 2
Oct. 13	6:09	5:23	11 h. 14 m.	− 3
Oct. 14	6:10	5:22	11 h. 12 m.	− 2
Total increase or decrease in number of minutes of daylight − 35				

5. The city in Europe would be having these seasons: March—spring; June—summer; September—autumn; December—winter. The city in Australia would be having these seasons: March—autumn; June—winter; September—spring; December—summer.

6. In the Northern Hemisphere in the autumn and spring the sun appears to rise almost due east and set almost due west. In the winter the sun seems to rise south of east and set south of west. In the summer the sun appears to rise north of east and set north of west. The children will need to use a marker such as a tree or post, to help them in making these observations.

Further Activities

1. Make a large pictorial map of the Western Hemisphere. Have children make illustrations showing what people might be doing in December in the Northern Hemisphere and in the Southern Hemisphere. Place the illustrations in the proper hemisphere. The title of the map might be "December in the Northern and Southern Hemispheres." Committees might make a series of pictorial maps—one each for March, June, and September in the two hemispheres.

2. Perhaps the children like one season better than another because they enjoy playing the sports that are associated with that

season, or they prefer spring and summer weather. A topic for discussion might be: If you wished to be where you could always enjoy your favorite sport or season, where would you go and when would you go there?

3. You might like to do this experiment to see how a beam of sunlight changes from day to day. Get a piece of cardboard about 12 inches square. Have a child cut a four-inch square from the center of it. Fasten the cardboard to the windowpane where the sun will shine through the opening. Then place a piece of paper on the top of a table or desk in the spot of sunlight. Have a child draw around the spot of sunlight. Write the date and exact time on the sheet of paper. A week later the children should do the experiment again. Do it exactly at the same time and put the paper in the same place as before. You may want to repeat the experiment in another week or two. Look at the shapes of the spots of sunlight. Notice whether the shapes change. Observe whether the spot gets closer to or further away from the window.

4. The children probably have observed that in your community a season may arrive earlier or later than the official day of the beginning of the season. For example, officially the first day of the winter season in the Northern Hemisphere is December 22, but where you live it may have been cold long before that. Perhaps the first snowstorm occurred the last of October or the beginning of November. Find out the highest and lowest daily temperatures in your community for one of the seasons. Does the season actually begin before or after the calendar date which begins the season? Does the season actually end before or after the calendar date which officially ends the season? Discuss the reasons for this.

5. Because our earth is tilted, beams of sunlight produce changing amounts of heat energy on the earth. This is an experiment the children can do: Fill the lids of two shoe boxes with dry garden soil. Place an outdoor thermometer in each lid. Cover the bulbs of each of the thermometers with the soil. Prop up one lid on the window sill so that it is almost in an upright position as the beams of sunlight strike it. Leave the other lid flat on the window sill in sunlight. Leave the two for about 10 minutes. Then record the temperature of each. In which soil is the temperature higher? How do the beams of sunlight strike the two lids? Which beams of sunlight produce the more heat energy in the soil?

6. Have the children make a chart showing the time of sunrise and sunset of cities north and south of the place where they live. Use one of these dates: June 22, September 23, December 22, or March 21. The *World Almanac* will help them in finding this information. After the chart is completed they will be able to answer these questions: Are the days longer or shorter on the particular date you chose in the cities north of where you live? Are they longer or shorter in the cities south of where you live? Do you know why? The children may want to check back into the chapter for their reasons.

Evaluation

As you and your children work through the experiments and demonstrations in this chapter, and as they read and discuss the material, evaluation will play an important part in your children's growth. The following suggestions may be useful as you observe the progress of each child:

1. Are the children making more careful observations?
2. Do children ask questions when they do not understand?
3. Do children understand the experiment or demonstration as it contributes to problem solving? Are children relating these experiences to the cause of seasonal change?
4. Do children respect the ideas of others in the group? Are children working more co-operatively?
5. Do children handle materials for experiments and demonstrations more effectively?
6. Observe whether children go to the table where materials are placed and work through experiments and demonstrations to gain more understanding or do they use their time unwisely?
7. Notice whether children gain understanding as they ask questions or make an explanation.
8. Have children make diagrammatic drawings showing the earth in relation to the sun at the different seasons. Do their drawings show understanding of seasonal change?

Bibliography

For the Teacher

Bernhard, Hubert J., Bennett, Dorothy A., and Rice, Hugh S. *New Handbook of the Heavens.* McGraw-Hill Book Company, Inc., 1948.

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It*, Chapter 8. The Dryden Press, 1951.

Craig, Gerald S. *Science for the Elementary-School Teacher*, New Edition Chapter 7. Ginn and Company, 1958.

Rey, H. A. *The Stars*. Houghton Mifflin Company, 1952.

For the Children

Blough, Glenn O. *Wait for the Sunshine*. McGraw-Hill Book Company, Inc., 1954.

Carpenter, Frances. *Our South American Neighbors*. American Book Company, 1950.

Fenton, Carroll Lane and Mildred A. *Our Changing Weather*. Doubleday & Company, Inc., 1954.

Owen, Russell. *Conquest of the North and South Poles*. Random House, Inc., 1952.

Parker, Bertha M. *The Sky above Us*. Row, Peterson and Co., 1953.

Wyler, Rose. *The Planet Earth*. Abelard-Schuman, Limited, 1952.

Zim, Herbert S. *The Sun*. William Morrow and Company, Inc., 1953.

Films

THE EARTH AND ITS SEASONS. (KB) 1 reel, b/w. Explains why we have changes of seasons.

SUN, EARTH, AND MOON. (ALF) 1 reel, b/w. John Kieran explains graphically as well as pictorially the reasons for day and night, and also the seasons of the year in various parts of the hemisphere.

WHAT CAUSES THE SEASONS. (YAF) 1 reel, b/w. Explains how the inclination and revolution of the earth cause our various seasons.

WHAT MAKES DAY AND NIGHT? (YAF) 1 reel, b/w. Demonstrates that the alternation of day and night is due to the rotation of the earth.

Filmstrips

THE CHANGING SEASONS. (PSP) color.

CLIMATE. (JH) color.

CLIMATE. (YAF) color.

DAY AND NIGHT. (YAF) b/w.

NATURE IN THE FOUR SEASONS. (EGF) color.

OUR EARTH IN MOTION. (JH) color.

OUR EARTH IS MOVING. (Curr F) color.

THE SEASONS. (YAF) color.

THE SUN AND OUR SEASONS. (JH) color.

WEATHER. (YAF) color.

WHAT MAKES WEATHER. (JH) color.

WHY DOES THE WEATHER CHANGE? (SVE) b/w.

WHY THE SEASONS? (SVE) b/w.

III

Energy and Plant Growth

The material in this chapter presents information on the role of energy sources within and also outside the plant. The importance of the sun's energy in the plant's manufacture of food is explained in terms of the role of water, minerals, light, and heat. The manner in which plant species continue on the earth is also described and illustrated by simple experiments and demonstrations.

Science Meanings for Children

The children in your group will have formed many concepts concerning plant growth. For example, they will know that plants need water, warmth, and sunlight to grow. However, in this chapter, the meanings developed place the emphasis on energy and its relation to growth.

These are some of the meanings which your group will gain as they discuss, experiment, observe, and read:

A great amount of energy is locked inside a seed.

Green plants need light energy from the sun in order to make food in their leaves.

Plants need water to manufacture their supply of energy.

Plants cannot use water when it is frozen in the ground.

Plants need certain mineral elements for proper growth.

In late summer or early autumn when there is less heat and light energy, deciduous trees lose their leaves. Evergreen trees lose their leaves at any time of the year.

Plants are able to make use of changing amounts of light and heat energy.

Non-green plants cannot use light energy from the sun to make food; they must use the chemical energy of green plants to grow.

The amount of light energy received by a region has a great deal to do with the kinds of plants that can grow there.

Each kind of plant can grow best at a certain temperature.

Plants have been on the earth a long, long time.

Some plants continue from one year to another by storing food in seeds or underground parts.

During the winter some plants go into a resting stage. While the weather is warm, they form buds in which are the next year's flowers and leaves. When there is again enough heat and light energy and water, these buds help the plant to grow quickly.

Changing amounts of light and heat energy and water affect the way plants grow from season to season and from one part of the earth to another.

Information for the Teacher

To grow, plants need energy. When a seed germinates, the young plant uses the energy in the food stored in the seed. However, this food is not enough to keep the young plant growing for any length of time. To continue growth, the plant must make more food. The plant uses this food to supply chemical energy for further growth.

Plants make food by a process known as photosynthesis. To

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A variety of corn has been grown in the classroom. The effects of heat and light energy on the plant's growth are being studied. Two other plants are also in the process of being studied.

make food, a plant must contain chlorophyll, the green material found in leaves and stems. Light energy is necessary for green plants to make food in their leaves. Most plants receive light energy directly from the sun, but it is possible for plants to grow by means of artificial light. In addition to light, in the process of food-making leaves also use the carbon dioxide gas which is present in the atmosphere. Carbon dioxide enters the leaves through openings, or stomata, on the underside of the leaves. Plants also need water to manufacture food. Through the root hairs, water enters the roots and is conducted through the stems into the leaves. In the presence of sunlight, these materials,—carbon dioxide gas, water, and chlorophyll,—undergo a chemical reaction in the leaves. The result of this change is sugar and oxygen. The plant changes most of the sugar into starch. In this form it is then stored in seeds and other parts of the plant.

In addition to sunlight, chlorophyll, carbon dioxide gas, and water, plants also need certain mineral elements that are used in the process of photosynthesis, or food-making. To make chlorophyll itself, a plant needs iron and magnesium. Other important mineral elements needed by plants for growth of roots, stems, leaves, and flowers are potassium, calcium, iron, sulfur, phosphorus, and nitrogen. These minerals are dissolved in the water found in soil.

Plants that have no chlorophyll cannot manufacture their own food. Plants such as mushrooms, toadstools, and molds are called fungi. They must get their energy for growth from dead or living things. For example, mushrooms get their foods from living or dead wood or leaves. Bread mold, which is another fungus, gets its food from bread or moist grain.

A special kind of agriculture called hydroponics may become a very useful way of producing large quantities of food in the future. In hydroponic farming, plants are grown in water to which have been added the necessary mineral elements for growth.

In some regions at certain times of the year plants must live under desertlike conditions. In autumn when the days grow shorter than the nights, parts of the earth receive less light and heat energy from the sun. In some of these regions the water in the soil freezes. In other regions the dry seasons, when there is little rainfall, are the most difficult times for plants to live through. In either of these cases there is no water in the soil which plants can use in the manu-

facture of food. In addition, plants give off much water through their leaves. There is an almost constant flow of water from the soil to the leaves of plants. Here the water not needed for photosynthesis is given off to the surrounding air. When there is no water available in the ground, plants would shrivel and die if there were no way of preventing loss of water through their leaves.

Plants survive a lack of water in various ways. Some trees lose their leaves in autumn in cool regions. These trees are called deciduous. Before each leaf falls, a thin separation layer grows at the base of its leafstalk. When the separation layer is completely formed, no water reaches the leaf and the leaf falls, leaving a leaf scar. Some deciduous trees and other plants have a few dead leaves remaining on the branches during the winter. On these plants the separation layers may not have completely formed.

In regions such as Southern California, plants lose their leaves in summer rather than in the autumn. In these regions plants lose their leaves during the long, hot days of summer when there is little rainfall.

Evergreen plants lose their leaves at any time during the year. This happens whenever the separation layer forms. Many evergreen plants have needlelike leaves. These plants lose less water through their leaves than do those plants which have broad leaves. Through the winter, food-making may go on in the leaves of evergreen plants when there is enough light energy; however, it goes on at a slow rate.

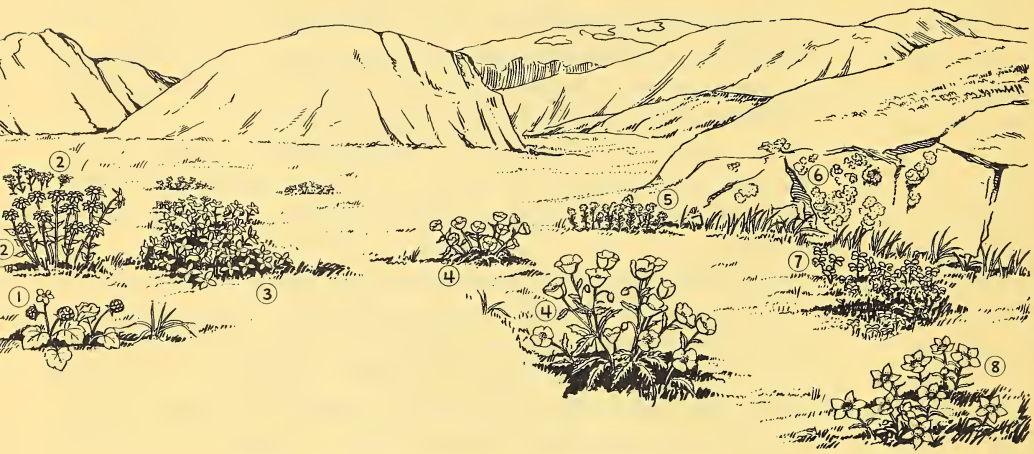
During the summer and early autumn leaf buds and flower buds form on the branches of trees and shrubs. Buds are important to plants because they contain the flowers, stems, and leaves for the next year's growth. Plants use some of their energy to form buds.

The varying amounts of light energy received by a region determine to a great extent the kinds of plants that grow there. Because of the long hours of sunlight in summer in some parts of Alaska and Canada, large crops of hay, wheat, potatoes and other vegetables grow quickly. Some plants need more than twelve hours of sunlight to bloom and make seeds. Other plants bloom only when there are fewer hours of sunlight. Most plants, however, probably bloom when they receive either little or much light energy from the sun.

Varying amounts of heat energy also affect plants' growth. Scientists have experimented with plants at different temperatures.

Some plants survive at temperatures far below freezing, but the general range of temperature within which plants can grow and make food is from about 32° F to 122° F. Each kind of plant has an optimum temperature at which it grows best.

The diagram below is a key to the arctic plants included in the illustration on page 65 of *Experimenting in Science.* It is not intended that your group attempt to identify these plants. However, there might be interest on the part of one or more of the children in



1. Cloudberry
2. Arnica
3. Fireweed
4. Arctic poppy
5. Alpine everlasting
6. Lichens
7. Purple rocket
8. Mountain avens

doing a bit of research to learn something about some of the more unfamiliar species. In that case this diagram may be of assistance to you.

Many plants such as weeds, garden flowers, and crops survive changes in amounts of heat and light energy by forming seeds. Many of these plants grow, blossom, make seeds, and die in the autumn. But their seeds will produce new plants the following spring or summer when conditions are right for their growth. Food stored in the seeds helps the young plants to start growing.

Some plants store food in their underground parts, and the parts

of the plants above ground may die. The underground parts called bulbs, stems, corms, rootstalks, or tubers remain dormant through the winter. The following spring or summer, when there is again enough heat and light energy and moisture, new plants grow from the buds in these underground parts.

The photographs on page 50 of this Manual show underground parts of plants. Although commonly called roots or bulbs, these are more truly underground stems in which food is stored by the plants. The following information may be helpful. Onions and hyacinths are common plants which grow from bulbs. Sweet potatoes are tubers. Dahlias and iris grow from rootstocks. Another name for rootstock is rhizome (rī'zōm). Common plants which grow from corms are crocuses and gladioli.

The amounts of heat, light, and moisture that plants receive vary from one part of the earth to another as well as from one season to another. Changes in amounts of moisture and energy affect plant growth.

Ways of Working with Children

Energy and Plant Growth may be used after the preceding chapter, *Why the Seasons Change*, or you may wish to present the material in this chapter at some other time. The material might be used effectively in the autumn or spring or at both times for making comparison of plant growth. As your children work through the chapter, they will have the opportunity of using many ways of learning. They will find opportunities for experimenting, discussing, observing, and reading.

A trip into the community to observe changes in plants will also stimulate children's thinking about plants and how they grow. Or you may wish to initiate the study by using the picture on pages 52–53 of *Experimenting in Science*. Let children relate their experiences in growing plants. Some may have observed a sunflower in bloom as it turns toward the sunlight. Many children will have planted seeds and studied how they are scattered, but few will realize the relationships of energy and plant growth. You will want to guide their discussion in that direction, particularly relating their ideas of heat, light, and chemical energy gained from the two preceding chapters, *Energy Everywhere* and *Why the Seasons Change*.

Let an individual child or a small group plant several sunflower seeds and record their growth. Since it will take some weeks for the seeds to grow, keeping a record of what happens and the corresponding dates will stimulate and keep alive an interest in the experiment. Experiments with plants often extend over a period of several weeks. If you plan to have the children make periodic progress reports, it will help to keep the groups interested in what is happening.

The question "What starts a plant growing from a seed?" on page 54 of *Experimenting in Science* will stimulate children's thinking. They will probably mention water and warmth as two factors which start seeds germinating. Reading the following pages will verify some of their ideas as well as suggest other experiences they can have in answering the questions proposed. The material on seeds on pages 109–111 of this Manual might also be of interest. It is tied in with a discussion of forests and conservation of trees, but the material could also be adapted to amplify the discussion of energy and plant growth.

The experiment on page 55 of *Experimenting in Science* to see how seeds begin to grow will probably take several days before the kernels split open and the roots appear. Have the children look at the roots through a magnifying glass. They will also be able to observe the root hairs. Have them compare the root hairs they see with the close-up picture of root hairs on page 56 of *Experimenting in Science.*

If soil is exposed in a road cut or ditch near your school, children may see the depth to which some roots of plants grow to get water. Some children may be interested in digging up weeds in their gardens or, if permission is obtained, from an empty lot. The group will observe the difference in length of roots of different plants.

In doing the experiment on page 57 of *Experimenting in Science,* children will be surprised and fascinated with the pattern made by the roots as they dissolve the mineral elements of the marble. No doubt some of the children will want to repeat the experiment. Bring out the fact that calcium is one of the elements found in marble.

Hydroponic farming mentioned on page 58 of *Experimenting in Science* is an interesting way of growing plants. Current magazines often carry articles describing this kind of farming.

Look at the pictures of leaf scars on page 59 of *Experimenting in*

Science. Take the class or a group into the schoolyard or a park to examine leaf scars. If magnifying glasses are available, they will be useful in seeing the leaf scars in greater detail. Note that leaf scars are different on various kinds of plants. Encourage children to look at the leaf scars on trees in their own yards or neighborhoods. Discuss with them their behavior in making observations on other people's property.

Study the illustration on page 62 of *Experimenting in Science* showing the sources of energy that green plants use in growing. To further clarify the thinking of children, after reading the material on pages 62 and 63 and discussing the illustrations, you may want to have several children draw diagrammatic sketches on the blackboard showing how green plants make food and how fungi get their food for growth.

Discuss the chart on page 64 of *Experimenting in Science* which shows the length of day at different places in North America on June 22. Have children recall what they learned in the chapter, *Why the Seasons Change,* about why the number of hours of sunlight varies from day to day. Suggest that the children find out the number of hours of sunlight on June 22 where they live. Then they can discuss the length of day and its effect on the kind of plants that grow in their community.

Help children find out what the temperature was in the community on the hottest and coldest days of the year. Compare the findings with the information given on pages 65–66 of *Experimenting in Science.* Discuss temperatures in your community and their effect on plant growth.

Have the children do the experiment with the cupful of soil suggested on page 68 of *Experimenting in Science.* Compare their results with those illustrated in the text. If they experiment with soil from different places, they will discover differences in the number of seeds. Help the children read carefully to follow directions in doing the experiment described on page 69 of *Experimenting in Science.* Doing experiments is a very good way of learning, but it is wise to guide children toward using reliable sources to check their observations and ideas.

In the autumn have children examine the buds on a low-branched deciduous tree growing in the schoolyard or a nearby park. If there are some leaves still on the tree, pull them slightly. The children

will discover that the leaves are almost ready to fall. They can see the new buds that were formed for the next year's growth. Have them feel the buds. Some of them are sticky; others may be covered with fine hairs. A magnifying glass is useful in helping children see details.

The suggestion on page 71 of *Experimenting in Science* will help each child to make a more detailed study of the buds on a branch or shrub. Have each child tag his branch and watch it for several months, noting particularly the changes in the size of buds and when they open. The series of observations might start in the autumn and continue on into the spring. A series of drawings with a record of the dates might be made. These would show the changes from one season to another. By placing the drawings on a bulletin board, individual children can compare their observations.

In the early spring children might bring a twig from different shrubs or trees into the classroom for observations. Discuss the proper cutting of the twigs so as not to injure the shrub or tree. Put the twigs in water and place them in a sunny window. Observe the changes each day. Open some of the buds. Toothpicks are useful in helping to unfold the leaves within the buds. Some of the buds contain leaves and others contain flowers. Children may be surprised when they discover that oak, maple, and other trees have beautiful flowers.

It might be of interest to have children examine bulbs, tubers, rootstocks, and corms if samples of each are available. Otherwise the photographs on page 50 of this Manual may be helpful in supplementing the material on page 72 of *Experimenting in Science.* Again it should be emphasized that the focus should not be on identification, but upon the energy stored in the food in these underground parts of plants.

Materials Needed

blotting paper, or paper towels
box, cardboard
bulb, onion
corm, crocus or gladiolus
flowerpots
food coloring, red
geranium plants, 2
jar, glass
magnifying glass
marble, piece of highly polished
potatoes, white and sweet

rootstock, dahlia
seeds: bean, corn, radish, sunflower, wheat
soil
toothpicks
tumbler, glass
twigs, with buds growing on them

Some Things to Think About

See suggestions for children, pages 74–75, *Experimenting in Science.*

1. You might guide children's thinking by suggesting such problems as: How did the discovery of seeds change the kinds of food people ate? How did it change the kinds of clothing people wore? What products come from plants? How did the discovery of seeds change the kinds of work people did for a living?

2. Have an individual child or committee do the experiment suggested. Have them keep a record of the observation they make. Encourage children to read back into the chapter to get information as to why the plants may produce flowers.

3. If children live where plants similar to wild morning-glories are pests, encourage them to dig up such a plant and observe the extensive root system and underground parts that grow into new plants. The material in the chapter will help children in arriving at an answer. An individual child or a committee may also wish to contact the county extension agent for information regarding the eradication of pest plants which propagate themselves through underground parts.

4. Guide children to observe wise practices in collecting only those twigs necessary for classroom use and in extending the proper courtesies when getting the twigs from other people's property. Help children to keep records of their observations. The flower buds open first on forsythia and willows. On a lilac twig, the leaf buds open before the flower buds. If you should want to force the buds, immerse them in warm water for several hours.

5. Encourage children to reread the material in the chapter if they are not sure of the answer. The florist would plan his plantings and displays to take advantage of the changing length of day and the time of year that each plant would bloom. He would then have one plant in bloom after another.

6. An individual child or committee may want to do this experiment. Have the children compare the results of their experiment with

Iris rootstock

Sweet-potato tuber

Onion bulb

Photographs by Lynwood M. Chac

Gladiolus corm

the illustration on page 75 of *Experimenting in Science.* They will note that on the plant which received less sunlight, the leaves faded from green to yellow as the chlorophyll became less.

Further Activities

1. Let children do this experiment to see how seeds grow: Partly fill a drinking glass with soil. Plant several kinds of seeds, such as bean, radish, and wheat, next to the glass. Keep the soil moist. Keep a record of the length of time it takes for the roots to grow from each kind of seed. Look at the roots and root hairs under a magnifying glass. Notice the length of the root hairs on the different kinds of plants.

2. Have a committee or individual do this experiment to observe how the water passes through the root hairs, through the stem, and into the leaves. Plant several bean seeds in a pot of soil. After several weeks, when the leaves are growing on the plants, dig the plants up and carefully wash away the soil. Place the roots of the plants in a glass of water to which red food coloring has been added. Notice the red water move slowly through the roots into the stems and into the leaves.

3. Have each child select a particular plant in the schoolyard, at his home, or some other place. Have him keep a pictorial and written record of the changes he observes from week to week or through the different seasons.

4. Visit a greenhouse to see how light and heat energy are controlled so plants can grow and bloom during the winter.

Evaluation

As you work with children in guiding their experimenting, observing, reading, and discussing, you may find some of the following suggestions useful in determining the growth each child is making:

1. Do children understand the purpose of the experiment they are doing? Do children not doing experiments show an interest in what others are doing? Do they look at the records being kept of the experiments?

2. Notice whether children are suggesting other experiments which will contribute to the problem at hand.

3. Are children growing in their ability to make more careful observations?

4. Are children becoming more aware of the changes in plant life evident in their environment?

5. Some children like to keep records in booklet form of experiments done in class. Do they clearly state the directions for doing each experiment? Are results of the experiment stated in terms of the purpose?

6. As the year progresses, notice whether children are contributing observations of plant growth and seasonal change.

7. Have children make a pictorial chart showing how plants continue on the earth. Such a chart will help you observe the learnings of individuals as they contribute to the planning and carrying out of plans.

8. Do the illustrations children make show a grasp of the meanings being developed in class?

Bibliography

For the Teacher

Craig, Gerald S. *Science for the Elementary-School Teacher*, Chapter XVI. Ginn and Company, 1947.

Jauss, Anne Marie. *Discovering Nature the Year Round.* Aladdin Books (E. P. Dutton & Co., Inc.), 1955.

Zim, Herbert S. *Plants: A Guide to Plant Hobbies.* Harcourt, Brace and Company, 1947.

Zim, Herbert S., and Martin, Alexander C. *Trees.* Simon and Schuster, Inc., 1952.

For the Children

Blough, Glenn O. *Wait for the Sunshine.* McGraw-Hill Book Company, Inc., 1954.

Cormack, Maribelle B. *The First Book of Trees.* Franklin Watts, Inc., 1951.

Fenton, Carroll Lane, and Kitchen, Herminie B. *Plants That Feed Us: The Story of Grains and Vegetables.* The John Day Company, 1956.

Hylander, Clarence John. *Trees and Trails.* The Macmillan Company, 1953.

Lucas, Jannette May. *Indian Harvest.* J. B. Lippincott Company, 1945.

Pistorius, Anne. *What Tree Is It?* Follett Publishing Company, 1955.

Podendorf, Illa. *True Book of Trees.* Childrens Press, 1954.

Stefferud, Alfred. *The Wonders of Seeds.* Harcourt, Brace and Company, 1956.

Sterling, Dorothy. *Trees and Their Story.* Doubleday & Company, Inc., 1953.

Van Dersal, William R., and Graham, Edward H. *Wildlife for America.* Oxford University Press, Inc., 1949.

Wall, Gertrude Wallace. *Gifts from the Grove.* Charles Scribner's Sons, 1955.

Zim, Herbert S. *What's Inside of Plants?* William Morrow and Company, Inc., 1952.

Films

ARCTIC BORDERLAND IN WINTER. (Cor) 1 reel, b/w & color. Shows how living things adapt to unusually difficult living conditions.

ATOMIC GREENHOUSE. (HFC) 1 reel, b/w. Illustrates how a plant takes in and uses the various elements in the soil.

EMERALD CLOAK OF SPRING. (VP) 1½ reels, color. Shows the changes which take place in nature in the progression from winter to the full bloom of spring.

FUNGUS PLANTS. (EBF) 1 reel, b/w. Describes the growth and reproduction of mushrooms, molds, and other fungi. Gives a close-up view of gills and spores.

LEAVES. (EBF) 1 reel, b/w. Describes the structure, function, and types of leaves. Shows in detail the parts of a leaf and illustrates the arrangement of cells and veins in the process of making food.

LIFE OF A PLANT. (EBF) 1 reel, color. Shows growth of a flowering pea plant, seed germination, growth of stems and roots, and processes going on inside the plant. Time-lapse photography and animated drawings are used.

LIFE OF PLANTS. (UW-Govt) 1 reel, b/w. Describes by means of time-lapse photography how seeds germinate and how roots, stems, leaves, and flowers develop.

POWER OF PLANTS. (ALF) 1 reel, b/w. Time-lapse photography reveals the physical power of plants in their indomitable effort to reach the sun and fulfill their growth.

ROOTS OF PLANTS. (EBF) 1 reel, b/w. Shows various kinds of roots. Describes structure, processes of growth, food and water intake, and sensitivity. The function of root hairs is explained.

SEASONAL CHANGES IN TREES. (Cor) 1 reel, b/w & color. Scientific study of the seasonal changes in trees.

WONDERS OF PLANT GROWTH. (CW) 1 reel, b/w & color. By means of time-lapse photography, two children are shown experimenting in growing plants from seeds.

Filmstrips

BEHAVIOR OF PLANTS. (Curr F) color.

HOW FLOWERING PLANTS GROW AND REPRODUCE. (SVE) color.

HOW TREES GROW. (PDP) b/w.

TREES AND FLOWERS IN THE FOUR SEASONS. (EGF) color.

TREES—THE OLDEST AND LONGEST LIVING THINGS. (PDP) b/w.

IV

Animals and Seasonal Change

Changes in the amount of energy through the year bring about seasonal changes. All the many changes in energy have an effect upon animals. The effects of some of these changes on cold-blooded as well as warm-blooded animals are developed through discussion and experimentation. Animals survive from year to year because they are more or less adapted to the changes which occur. Various types of adaptation such as hibernation, migration, and physical changes are discussed. Many theories are presented to explain why these changes and adaptations have evolved. These explanations are developed in such a way as to stimulate pupil discussion and speculation and to promote, in so far as possible, a quest for further information.

Science Meanings for Children

Children will bring many conceptions regarding animals to this study. Some children will have misconceptions and a few may hold superstitious beliefs regarding animal migration and hibernation. As you and your children work through this study, the following are some of the meanings you may wish to develop:

The changes we call seasons are brought about by changes in the amounts of energy which reach parts of the earth.

Animals are affected by the changes taking place around them.

Changes in temperature affect animals. Some animals are more active when the temperature drops; other animals are less active.

The temperature of some animals changes as the temperature of the air about them changes. These animals are called cold-blooded. Another group of animals have a more-or-less constant temperature, no matter what the temperature of the air is around them. They are called warm-blooded.

Winter is a difficult time for many animals to stay alive, because the amounts of water, food, and light and heat energy are decreased.

Animals live through severe winters in a variety of ways: Some animals leave the region and return when there is again sufficient heat and food to stay alive; some animals grow thicker coverings of fat, fur, or feathers; some animals migrate; some animals hibernate.

There are many theories about the causes of migrations.

In some places the hot, dry season is the most difficult time for many animals to stay alive. They stay alive by changing their habits. Some animals hunt food at night when there is less heat energy than in the daytime. Some animals are inactive and live in protected places until it rains. They then become active again.

Information for the Teacher

As the seasons change, most animals change their way of living and thus survive. During the summer months when the earth receives greater amounts of energy from the sun, food is plentiful and animals thrive in many regions with little difficulty. However, with the coming of winter to a given region, the amount of energy from the sun grows less, the temperature of the air changes, and food may become so scarce that many animals perish.

Severe winters are difficult periods for most animals, but changes in temperature and in amounts of food and water are met by them in different ways. Some animals, such as snakes, flies, turtles, and frogs, are easily affected by changes in the temperature of the air, since they are cold-blooded animals. The temperature of their bodies changes as the temperature of the air around them changes. During cold weather, cold-blooded animals must seek some kind of protection, for low temperatures make them so sluggish they cannot move. If the temperature around them is below freezing, they themselves will freeze. Other animals, like birds and mammals, are warm-blooded animals. The temperature of their bodies remains rather constant even though they may live in a place which is quite cold. Many warm-blooded animals can be almost as active in cold weather as in warm.

Many animals protect themselves, not consciously, of course, against the extreme cold of winter by finding shelter in the ground, in caves, and in hollow logs or trees. These animals hibernate. During the period of hibernation, breathing, circulation of the blood, and

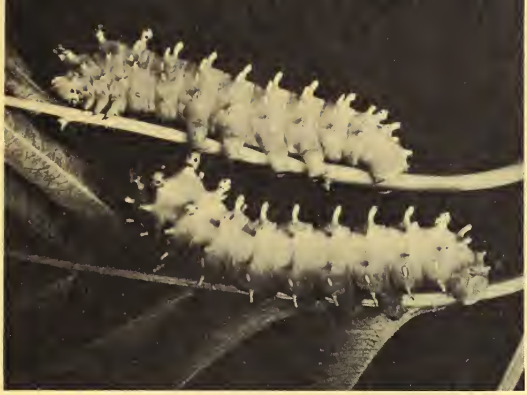
other bodily processes of these animals go on at a very slow rate. In fact, hibernating animals exhibit few of the characteristics of active animals. Sometimes animals do not survive the period of hibernation, because their body temperatures fall below freezing and they die.

Many hibernating mammals such as field mice, beavers, squirrels, opossums, raccoons, and skunks emerge at intervals during the winter season. There are degrees of hibernation; that is, some animals stay in hibernation longer than others. Woodchucks remain in hibernation all winter. During the summer a great amount of fat is stored in their bodies on which they live while hibernating. Of course if woodchucks do not have an opportunity to store great amounts of fat during the summer, they may not survive the winter.

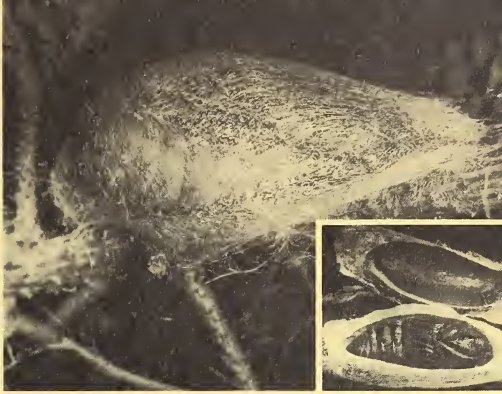
Many mammals, such as wolves, weasels, foxes, and mink, are protected by coats of fur which grow thicker in winter, and so they remain active during the cold weather. Even though food may be scarce during the winter, they can usually feed on animals such as rabbits, deer, or sheep. In some communities wolves may cause great economic losses to ranchmen, as they attack sheep and calves in search of food.

Tracks on the snow often show a record of how a particular kind of animal gets its food. Rabbit tracks reveal that these animals dig out plants and eat young shoots. Sometimes they attack young trees, gnawing off the bark and eating the green layer beneath it. Deer, elk, and other hoofed animals paw away the snow, feeding on dead grass. If food is scarce, they may feed on the buds or young branches of trees.

Many adult insects die as a result of lower temperatures in autumn and winter. A few, however, like houseflies, crawl into cracks in the walls, under boards, or into similar places for protection. They remain inactive until the air grows warmer. Then they emerge and lay eggs. Most insects survive the difficulties of winter weather in the egg, larva, or pupa stage. In the autumn many insects lay eggs. The female locust, for example, lays eggs in a small hole in the ground. There they remain until the following spring when the energy from the sun warms the ground and they hatch into young locusts. Other insects have similar habits which help them survive the difficulties of winter.



1. Caterpillars of the Cecropia moth feeding



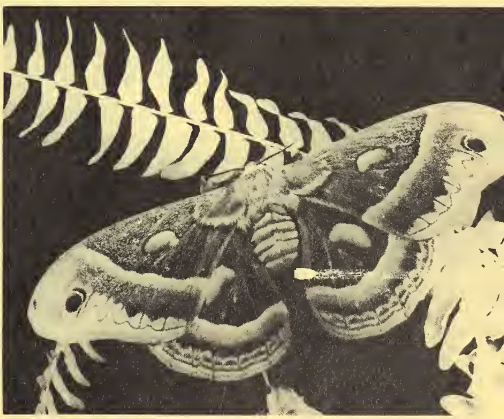
2. Cocoon, with inset showing cut-away view of pupa

3. Moth emerging from cocoon

4. Moth almost fully developed

The Cecropia-moth caterpillar, or larva, spins a cocoon where it remains during the pupa stage. Later an almost fully-grown Cecropia moth emerges.

Photographs by Linwood M. Chase



5. Adult Cecropia moth

Some insects, like moths and most butterflies, lay their eggs during the spring and summer. Because of the warm days the eggs soon hatch into larvae. They feast on the leaves of plants. When autumn approaches, the larvae have spun cocoons or made chrysalises. They remain in the pupa, or resting stage, during the winter months.

Many animals, particularly birds living in the Temperate Zones, migrate periodically to escape the difficult days of winter. Just why certain animals migrate is not clearly understood. The chief cause is probably lack of food. Fur seals and whalebone whales move southward with the approach of winter because their food supply becomes less plentiful. They move northward again in the summer when food is again easy to obtain. Some scientists think that bird migrations may be affected by the hours of sunlight. Evidence shows that certain birds begin their migration at a particular time of the year regardless of weather conditions and availability of food. The constant factor from year to year seems to be the number of hours of daylight when migrations begin. Changes in the hours of sunlight may bring about changes in the bodies of birds which cause them to make nests and breed in their northern homes. In the Northern Hemisphere there are larger feeding and breeding areas available than in the Southern Hemisphere. These may have led to annual migrations of birds and may help to explain why birds go north to nest. No one theory seems to explain all the things known about animal migrations.

Most birds follow rather definite routes as they migrate year after year. Some birds, such as the golden plover, arctic tern, blackpoll warbler, and bobolink, migrate great distances each year. The map on page 61 of this Manual gives further information on migration routes of various birds. Birds travel at various speeds and altitudes. Some birds spend the day feeding and fly at night, and others migrate during the hours of sunlight. Not all birds survive the period of migration, for they encounter many dangers such as strong winds and storms and sudden changes in weather.

Instead of migrating hundreds of miles southward, some birds and other animals such as elk, deer, and mountain sheep migrate from higher altitudes to lower altitudes as winter approaches. Some birds do not migrate, but remain at the same place throughout the year. Usually these birds do not eat insects, but during the unfavorable winter months they live on seeds and other available food.

Another animal which migrates is the monarch butterfly. Insects do not usually migrate, but the monarch butterfly survives changes in temperatures by migrating southward, just as many birds do. Hundreds of butterflies migrate together until they reach their final destination.

In some parts of the earth, periods of heat and dryness are the most difficult times for animals to stay alive. Turtles and other reptiles, as well as some amphibians, protect themselves from drought conditions by digging into wet soil. They remain there until it rains. Still other animals change their usual habits of hunting food during the daytime and hunt food at night when the temperature of the air is lower.

The adaptation of animals to drought and high temperatures is called estivation. It differs from hibernation in that it happens during periods of extreme heat and dryness. This adaptation protects animals from dying from lack of water.

Ways of Working with Children

You might initiate the study of *Animals and Seasonal Changes* by having your group make a list of changes they observe around them. You may want to write the list on the board. Their list will probably include changes they see in the landscape and changes in the weather. You will want to have them think of some of the animals they see in their community during the summer, in autumn, and other seasons. If this study is made in the autumn, have children bring out any changes they observe in animal life.

Another approach which you may wish to make in initiating the study and motivating discussion is to introduce the illustrations on pages 76–77 of *Experimenting in Science*. Discuss the various conditions under which animals in the community live. Are they similar or different from those found in the illustrations? Children might like to make a list of the ways they have observed in which animals meet seasonal changes. This list might be made into a chart for future reference. As children work through the experiences in the chapter, they may want to add to their original list. Point out from time to time during discussions that animals do not consciously make adjustments to changes in the various seasons. As far as we know, their behavior is entirely instinctive.

Help children recall that weather changes are the result of the way the energy of the sun reaches our tilted earth. You might want to have a child show briefly the demonstration with the globe and light given in the chapter *Why the Seasons Change.*

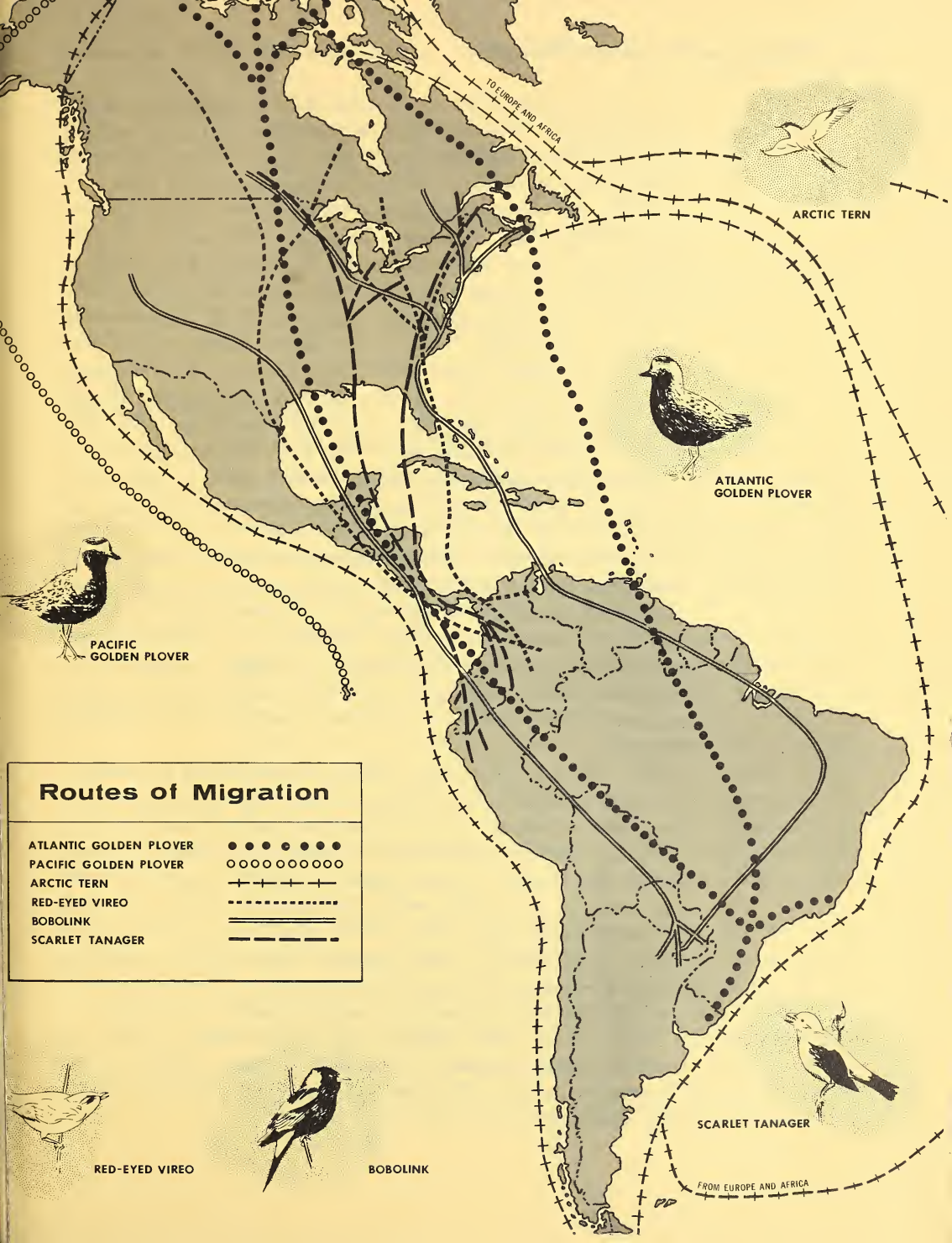
Bring out the fact that changes in temperature are probably the most important changes that affect animals. At this point you may suggest that the group recall the variation of temperature between the coldest and hottest day in the year which was brought out in the previous chapter, *Energy and Plant Growth.* To observe the effect of changes in temperature on an animal, have a committee do the demonstration on pages 78–79 of *Experimenting in Science.* Children will want to read the material on these pages to find out how changes in temperature affect other animals than the flies used in the demonstration.

The words "cold-blooded" and "warm-blooded" to describe animals may be unfamiliar to most children. To give meaning to these words, use the demonstration with the flies and also the illustrations on pages 80 and 81 of *Experimenting in Science.* You might propose such questions as: "What did we do to the condition of the air around the flies when we set the jar in a pan of ice?" "What might the air be like in winter around animals such as those in the illustrations?" "What would the air be like in summer?" The material on pages 80–83 will clarify their thinking in terms of cold- and warm-blooded animals.

Your children may live in a part of the country where winter is not the most difficult time for animals to live. If this is so, some members of your group may have lived where they have observed severe winter conditions and will want to relate their experiences with animals. Others will have an enriching experience in reading and discussing the materials on pages 83–85 of *Experimenting in Science.*

Before reading and discussing the material on the remaining pages of this chapter, the group might like to refer to their original list of ways in which animals live through difficult times. They may want to delete from or add to their list.

As the children discuss the migrating animals in the illustrations on pages 86 and 87 of *Experimenting in Science,* they might like to theorize as to why birds and other animals migrate. When children read the text and other sources, they will find that there are several theories, but no one theory seems to give the answer to this puzzling


TO EUROPE AND AFRICA
ARCTIC TERN
ATLANTIC GOLDEN PLOVER
PACIFIC GOLDEN PLOVER
Routes of Migration
ATLANTIC GOLDEN PLOVER
PACIFIC GOLDEN PLOVER
ARCTIC TERN
RED-EYED VIREO
BOBOLINK
SCARLET TANAGER
RED-EYED VIREO
BOBOLINK
SCARLET TANAGER
FROM EUROPE AND AFRICA

question. You may want to point out that birdbanding has helped people learn more about bird migrations. There may be an authorized birdbander in your community who could come and talk to the group. Have him bring an official birdband to show the class.

The routes of several migratory birds are shown on the map on the preceding page. You might have each child select some migratory bird found in the community or of particular interest to the individual. The migratory route might be shown on a map in some such way as in the illustration on page 88 of *Experimenting in Science.* This shows routes of the Atlantic golden plover. The route of the Pacific golden plover from Alaska to the Galápagos Islands is included in the map on page 61 of this Manual. If your school has an opaque projector, individual maps might be thrown on a screen when each child gives a report on his particular bird.

If there is an excavation near your school, similar to the one described on pages 92–93 of *Experimenting in Science,* it will be worth the effort to take a trip to see it. If the ground freezes in winter in your region, you will be able to observe the frost line in such an excavation when the weather is cold. Even if you live in a region where the winters are mild, it will be helpful to visit an excavation or road cut. Speculation as to the texture and temperature of the soil above and below a frost line will stimulate the children's interest in the animals which live in the soil. Then when children read that some animals hibernate below the frost line, it will have more meaning for them.

The habits of hibernating animals are fascinating to children. You may want children to select an animal in their environment or one they are interested in and have them find information from a variety of reading sources and make reports to the class. A series of drawings to show the class makes the report of each child more interesting to the child as well as the listeners. Children, if given the opportunity to be creative, have many ideas of how to give their reports in an interesting manner. Some children might like to make diagrams or "movies" (a modern twist—"television show") showing their particular animal in summer and then in winter.

Have children visit a dried-up pond, if it is possible, and get soil from the pond. Children will be amazed at their discoveries. The illustrations on page 96 of the text show some of the animal life they might find.

Materials Needed

bowl
cotton, absorbent
flies, 2 or 3 living
hammer
ice
jar, glass, with a metal screw top
nails
soil, bucket of, from a dry pond
thermometer, outdoor
wood, assorted pieces, to build a feeding shelf

Learning More about Animals

See suggestions for children, page 97, *Experimenting in Science.*

1. Children living in different parts of the United States and Canada will, of course, not observe the same changes. They may observe that some animals are getting heavier coats of fur, some animals are storing food, others are migrating, still others are spinning cocoons or making chrysalises. Guide children in making careful and accurate reports of their observations.

2. Children might keep their record with headings similar to these: Month—Name of Bird—Summer Resident—Winter Resident—Year-round Resident. Children will probably recognize few of the birds they see. Books may be found in public or school libraries which are helpful. *Birds of America,* edited by T. Gilbert Pearson, contains colored plates of birds which would be useful. However, it is more important that children become aware of the fact that some birds are in the community only in the summer or the winter, while others stay all year long. Often some person in the community knows a great deal about local birds and would enjoy telling children about them.

3. The feeding shelf on page 97 may suggest one kind that might be built for your class. Maintaining a feeding shelf can be a very enjoyable experience if careful plans are made. Place the shelf out of reach of cats and squirrels. A pan of water put on the shelf in dry weather helps to attract birds. Have children find out what foods to put on the shelf. These are some foods birds will eat: sunflower seeds, grains, bread crumbs, apples, and suet. The National Audubon Society, 1130 Fifth Avenue, New York, has information on birds

which you will find useful. You may want to show the film, *Attracting Birds in Winter*, distributed by International Film Bureau. It shows how two children built a feeding station in their backyard to attract birds.

Further Activities

1. Scientists in Canada, the United States, Mexico, South America, and other countries have learned a great deal about bird migrations by banding birds. Have a committee report on birdbanding. Encyclopedias will give information. Other reading sources listed in the bibliography may also be helpful.

2. Have children look under different-sized rocks in winter. They will probably find egg cases of insects or spider egg cases. Have them make a list of the animals they find. How are these animals meeting the difficulties of winter?

3. Let children select one migratory animal of particular interest to them. Find out where it stays in summer and winter. Show its migratory route on a map of the Western Hemisphere.

4. Take a trip in the autumn into the community to observe animals migrating, spinning cocoons, storing food, etc. After several weeks go to the same area to observe what has happened to animals since the last trip.

5. A group might make a mural showing the way different animals live through the seasons.

Evaluation

1. As you work with children throughout this study, you will be interested in noting whether children are making more careful and accurate observations of the animals they see in their environment.

2. Are children making more interesting as well as more accurate reports? Among your group you will probably find a wide range of differences in the reporting done by children. The important thing for you to note is the growth each child makes in terms of his own ability.

3. Invite another group to listen to the reports given by children. The invited group may be encouraged to ask questions of the chil-

dren making the reports. This will give you an opportunity to evaluate the learnings gained by children throughout the study.

4. The following suggestion for a chart may be helpful as you check on the learnings of your group. You may want children to prepare such a chart. It should include the animals which your particular group has studied.

HOW THE ANIMALS WE HAVE STUDIED LIVE THROUGH DIFFICULT PERIODS

Animal	Cold-blooded or warm-blooded	What it does to stay alive	Where it goes in winter
Frog	Cold-blooded	Hibernates	Burrows in mud in or near pond
Robin			
Bear			
Woodchuck			

5. Do the children contribute information from additional reading during discussions? Do they bring pictures of animals to show the group and for the bulletin board? Do they find and bring stories that relate to this study from newspapers and magazines?

Bibliography

For the Teacher

Craig, Gerald S. *Science for the Elementary-School Teacher*, New Edition, Chapter 20. Ginn and Company, 1958.

Jauss, Anne Marie. *Discovering Nature the Year Round.* Aladdin Books (E. P. Dutton & Co., Inc.), 1955.

Lemmon, Robert S. *How to Attract the Birds.* Doubleday & Company, Inc., 1947.

Lincoln, Frederick C. *Migration of Birds*, Circular 16 (1950), Fish and Wildlife Service, U.S. Department of the Interior.

For the Children

Andrews, Roy Chapman. *All about Whales.* Random House, Inc., 1954.

Blough, Glenn O. *Birds in the Big Woods.* Row, Peterson and Co., 1950.

Bullough, William Sydney and Helena. *Introducing Animals.* Thomas Y. Crowell Company, 1954.

Candy, Robert. *Nature Notebook.* Houghton Mifflin Company, 1953.

Carr, William H. *Desert Parade.* The Viking Press, 1947.

Dudley, Ruth H. *Sea Shells.* Thomas Y. Crowell Company, 1953.

Fenton, Carroll Lane. *Wild Folk in the Woods.* The John Day Company, 1952.

Fenton, Carroll Lane and Mildred A. *Our Changing Weather.* Doubleday & Company, Inc., 1954.

Fenton, Carroll Lane, and Pallas, Dorothy Constance. *Birds and Their World.* The John Day Company, 1954.

Goudey, Alice E. *Here Come the Deer!* Charles Scribner's Sons, 1955.

Green, Ivah. *Animal Masquerade.* Coward-McCann, Inc., 1955.

Liers, Emil. *An Otter's Story.* The Viking Press, 1953.

Marcher, Marion W. *Monarch Butterfly.* Holiday House, 1954.

Murie, Olaus J., *Field Guide to Animal Tracks.* Houghton Mifflin Company, 1954.

Parker, Bertha M., and Park, Thomas. *Animal Travels.* Row, Peterson and Co., 1953.

Pearson, T. Gilbert (editor). *Birds of America.* Garden City Books, 1947.

Perkins, Marlin, and others. *Marlin Perkins' Zoo Parade.* Rand McNally & Company, 1954.

Podendorf, Illa. *True Book of Insects.* Childrens Press, 1954.

Rounds, Glen. *Lone Muskrat.* Holiday House, 1953.

Webb, Clifford. *Animals from Everywhere.* Frederick Warne & Co., Inc., 1952.

Films

ANIMALS IN SPRING. (EBF) 1 reel, color. Shows activities and changes in animals in early spring.

ANIMALS IN SUMMER. (EBF) 1 reel, color. Pictures the activities of animals in summer and the struggle for survival.

ANIMALS IN WINTER. (EBF) 1 reel, b/w. Provides studies of various wild animals as they prepare for and live through the winter season.

ATTRACTING BIRDS IN WINTER. (IFB) 1 reel, color. Shows how to attract birds to your yard and what foods are suitable. Some common water birds in their natural habitats are shown.

THE BEAR AND ITS RELATIVES. (Cor) 1½ reels, b/w. Presents a scientific, zoological approach to the family of bears.

BIRD MIGRATION. (NAS) 1 reel, color. Pictures seasonal habits of migratory and non-migratory birds with animated map drawings of migratory routes and scenes of birds in their natural habitats.

BIRDS IN WINTER. (Cor) 1 reel, b/w & color. Pictures the food-getting habits and adaptations of birds commonly seen in winter in northern United States and southern Canada.

FLIGHT OF THE SEA BIRDS. (WLF) 1 reel, b/w & color. Story of the early migration of countless sea birds to beautiful inland mountain lakes.

HIGH OVER THE BORDERS. (NY Zool) 1½ reels, b/w. Tells the story of the annual migration of birds from North to South America and return.

INSECTS ARE INTERESTING. (DFP) 1 reel, color. Shows how insects live and how they adapt to seasonal change.

LIFE IN THE DESERT. (EBF) 1 reel, color. Depicts plant and animal life on the deserts of the American West. Stresses the effect of weather on desert life.

MAMMALS ARE INTERESTING. (EBF) 1 reel, color. Illustrates the characteristics of mammals by means of many different animals.

WATER BIRDS. (EBF) 1 reel, b/w. Shows several birds adapted to living in a shore environment. These include the brown pelican, egret, mallard duck, and Canada goose. An animated sequence shows the migration route of the Canada goose.

Filmstrips

ANIMALS AND SEASONS. (Curr F) 6 filmstrips, color. AIR MIGRATION; LAND AND WATER MIGRATION; HIBERNATION; ADJUSTMENT TO SUMMER; SEASONAL BODY CHANGES; SEASONAL HABITS.

ANIMALS IN THE FOUR SEASONS. (EGF) color.

MIGRATION OF BIRDS. (JH) b/w.

V

The Milky Way and Beyond

The questions relating to the universe which often arise during the free discussions of eleven- and twelve-year-olds have a rather personal reference: Where in this world are we? This chapter of *Experimenting in Science* seeks to provide information concerning the universe, and to orient the learner to the vast conceptions of space and time in the solar system, the Galaxy, and the universe. Throughout the chapter there has been an attempt to have the learning elements develop through the personal reference and experiences of children.

Science Meanings for Children

The children probably will know a good deal about the solar system and its various parts. Constellations of stars are something with which most children are familiar. As you look over the following meanings, you will see that the consistent thread of an enlarged concept of space is developed:

The Milky Way appears to be a band of pale-white light that stretches across the sky among the stars. The light of the Milky Way is coming from millions and millions of stars.

The Milky Way forms a complete ring around the earth.

The stars in the Milky Way seem to be packed closely together because they are all so very far away from us.

Each star in the Milky Way is far away from its nearest neighbor.

Distances in the sky are vast: The sun is about 93 million (93,000,000) miles from the earth; the next nearest star is more than 24 trillion (24,000,000,000,000) miles away from us.

Astronomers use the light-year rather than the mile to measure distances in the sky. A light-year is the distance that light energy travels in one year.

A constellation consists of stars which *appear* to be part of a single group. The stars which we see as a constellation are actually at quite different distances from us.

All the stars that we can see with the naked eye are part of a single system of stars called the Milky Way system or the Galaxy.

Our sun is a star.

Our star—the sun—and all the planets of our solar system are part of the Milky Way system.

The stars in our Galaxy seem to form a large wheel which is slightly thicker at the center, or hub.

The sun and its family of planets are about halfway between the center of the Milky Way system and its rim.

The whole Milky Way system, made of billions of suns, is moving through space.

The whole system is also turning like a huge wheel around its center. Each star moves along its own path around the center of our Galaxy.

There may be millions of other galaxies besides our own. One of these, the galaxy in the constellation Andromeda, is visible to the naked eye.

When you look at distant objects in the sky, you are looking across great spans of space and you are also looking into the past.

The Milky Way system belongs to a cluster of about nineteen galaxies. There are several hundred other groups of galaxies too.

All the groups of galaxies together make up the biggest group of all: the universe.

We may be living in a universe that is growing bigger all the time.

Information for the Teacher

Adults as well as children are always extremely curious about objects in the sky. *The Milky Way and Beyond* is a chapter which moves us out into space. To the unaided eye the Milky Way appears to be a band of pale-white light that stretches across the sky among the stars. Astronomers have found that the Milky Way is actually composed of millions of stars. Our solar system belongs to a vast system of stars called the Milky Way system or Galaxy. Our solar system takes but a small part of the total space occupied by the Milky Way system and an even more infinitesimal part of the vast reaches of space which make up the universe.

Our sun is a star and it is the most conspicuous object in the sky. But many of the stars you are able to see in the evening are two

hundred or three hundred times larger than our sun. The diameter of the sun is about 109 times the diameter of the earth, or approximately 864,000 miles.

Stars are on all sides of the earth, but we do not see stars in the daytime. Because the sun is so much nearer to the earth than any of the other stars are, its brightness blinds us to the stars shining in our daytime sky. But we see the stars in our evening sky. These stars seem to be arranged in groups which we call constellations.

Constellations consist of stars which appear to be in groups because we see them in the same part of the sky. But most of them are not groups at all. One star in a constellation may be trillions of miles farther away from the earth than other stars in the same constellation. Pages 105–107 of *Experimenting in Science* have an informative discussion of this subject, which you will want to consider carefully before taking up with your children. You may also find it helpful to read pages 129–137 of *The Stars* by H. A. Rey.

You will want to remind yourself that the study of constellations as such has little value if one is concerned merely with identification. It is the larger aspects—the sense of distance, time, and the immensity of the universe—which you will want to develop and emphasize.

Betelgeuse (bē'tl jooz), a star in the constellation Orion (ō rī'ŏn), has a diameter which is about 400 times greater than the sun. From one edge of Betelgeuse's disc to the other edge is a distance of approximately 216,000,000 miles. This distance is so great that the earth and sun could be placed in it with more than enough space for the earth to go around the sun at its present distance.

Some stars are very bright and can easily be seen with the unaided eye. Others are very dim and are almost invisible. But it is

This diagram shows the sizes of Antares and Betelgeuse in relation to the size of the earth's orbit.

CHART 3 · STARS IN ORDER OF APPARENT BRIGHTNESS*

Star	Constellation English name	Constellation Latin name	Color	Distance (light-years)	Meridian date at 9 P.M.
Sirius	Big Dog	Canis Major	Bluish	8½	Feb. 16
Vega	Lyre	Lyra	Bluish-white	27	Aug. 15
Capella	Charioteer	Auriga	Yellow	42	Jan. 24
Arcturus	Herdsman	Boötes	Orange-yellow	33	June 10
Rigel	Orion	Orion	Bluish-white	540	Jan. 24
Procyon	Little Dog	Canis Minor	Yellow-white	11	March 2
Altair	Eagle	Aquila	Yellow-white	16	Sept. 3
Betelgeuse	Orion	Orion	Reddish	300	Feb. 3
Aldebaran	Bull	Taurus	Orange	53	Jan. 14
Pollux	Twins	Gemini	Yellow	29	March 3
Spica	Virgin	Virgo	Bluish	120	July 28
Antares	Scorpion	Scorpio	Reddish	250	July 14
Deneb	Swan	Cygnus	White	400	Sept. 16
Regulus	Lion	Leo	Bluish-white	67	Apr. 9

*This chart is presented as background material for you. It is not intended that the material in it be taught to your children. The chart may be useful as you help children find answers to questions that arise concerning stars.

important to remember that a star may appear brighter than another because it is closer to the earth. It may not actually be larger and brighter. Sirius (sĭr'ĭ ŭs) is the brightest star in our sky, but Antares (ăn târ'ēz), in the constellation Scorpion, is more than 150 times as large. Antares does not appear as bright as Sirius, because Sirius is much closer to the earth.

Stars have different colors. Our sun is a yellowish star. Betelgeuse is a reddish star. This color difference is due to a difference in temperature. The temperature at the surface of our sun is about 10,000 degrees Fahrenheit. Betelgeuse has a surface temperature of about 5500 degrees Fahrenheit. The red stars are the coolest, the yellow stars are hotter, and the bluish-white stars are still hotter, having a surface temperature of about 70,000 degrees Fahrenheit.

The chart above lists some of the brightest stars which can be seen in the Northern Hemisphere. The stars are listed in order of their apparent brightness. Both the English and the Latin names are given for the constellations in which these stars are located. The meridian dates listed in the last column in the chart refer to the dates on which at 9 P.M. each particular star appears to be at its highest point in the sky for the year. These dates also indicate at which season of the year each star is most easily visible.

On pages 74–75 of this Manual simplified maps of the major constellations are shown. As you recall, the polestar can easily be located by continuing the line of the two "pointer" stars in the Big Dipper, as shown by the dotted lines on the star maps. Other constellations can then be located without too much difficulty.

The position of the earth in its orbit around the sun is slowly but continuously changing. However, the reason that we see different stars in the sky at various seasons of the year is not because the earth is in a different part of the sky. The North Star, or polestar, and the stars around it (often called circumpolar stars) are visible in the Northern Hemisphere on any clear night throughout the year. As the earth rotates, the stars seem to wheel in great circles, about the polestar. But as the earth revolves around the sun, each daily rotation moves it a bit farther on in its orbit. Therefore some of the stars which are visible at night at certain seasons of the year are actually in our daytime sky at other seasons although we cannot see them. The star maps on pages 74–75 will be helpful to you. From them you can see that the constellations around the polestar are visible to us throughout the year in the Northern Hemisphere.

Our sun is 93,000,000 miles away from us. This is a tremendous distance. But when compared with distances to other stars, the sun can be thought of as very close to the earth. The distance to the next nearest star, Proxima Centauri (prŏk'sĭ mȧ sĕn tô'rī), is about 24 trillion (24,000,000,000,000) miles. A trillion equals one million million. Sirius, the brightest star in our sky, is approximately 50 trillion (50,000,000,000,000) miles away.

Because the distances are so great, astronomers find it very inconvenient to measure distances in the sky by means of miles. They have adopted a unit of measure called the light-year. Light travels at a rate of 186,000 miles per second. In a year light travels approximately 6 trillion miles. The distance that light travels in one year is called a light-year.

On page 113 of *Experimenting in Science* you can see a picture of our Galaxy. The diameter of the Milky Way system has been estimated to be about 100,000 light-years. At its center it has a thickness of about 10,000 light-years. All the individual stars which you can see with the naked eye belong to our Galaxy.

As you work with children on this chapter, you will want to emphasize that a light-year is primarily a measure of distance rather

than of time. *Light-year* is simply a convenient term to express a distance of 6 trillion miles. For example, our Galaxy has a diameter of about 600 quadrillion (or 6 followed by 17 zeros) miles. 600 quadrillion is 100,000 times 6 trillion. How much simpler it is to express this tremendous distance as 100,000 light-years.

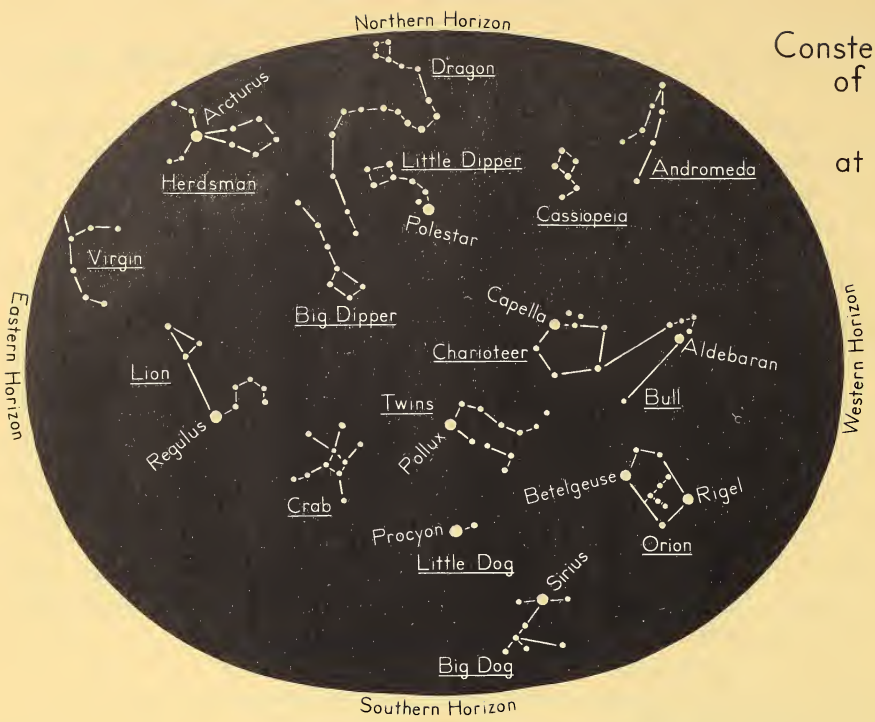
Our Galaxy is not alone. There are many other galaxies within the range of modern telescopes. In fact, there are probably millions of other galaxies. These other galaxies are so far away that most of them cannot be seen with the naked eye. Look at the constellation Andromeda (ăn drŏm′ē dă). Of course the stars in this constellation belong to our Galaxy. There is a hazy spot of light in the Andromeda constellation. Astronomers studying this spot of light found that it is so far away that it is not even a part of our Galaxy. It is actually a whole system of stars in itself. The blur of light is a galaxy. This galaxy which appears to be in the constellation Andromeda is actually more than a million light-years away from our Milky Way system.

Ways of Working with Children

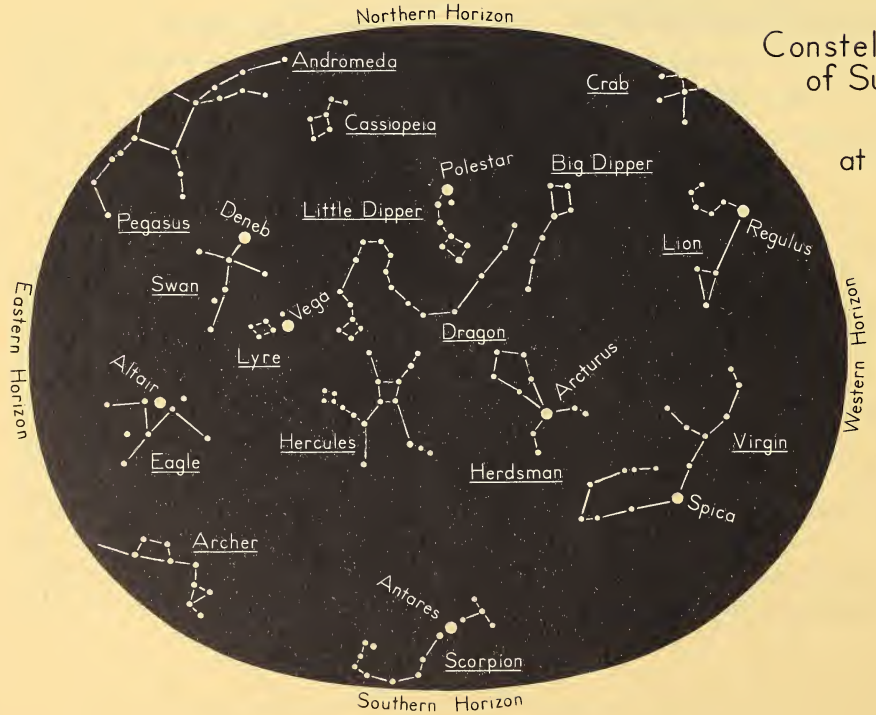
The opening spread of this chapter can be used as a point of departure with the children to bring out the concepts they already have concerning the Milky Way, the universe, and stars in general. This free discussion might be considered an initial form of evaluation. As the children work with the materials and ideas in the chapter, you will want to note how their ideas have changed, developed, and matured.

The children ought to be encouraged to observe the Milky Way firsthand. A committee may undertake the observation and report back to the class, or individual members of the class may undertake the observation. Ideally, it would be most advantageous if an evening field trip could be arranged for the specific purpose of observing the Milky Way and other features of the night sky.

If such a trip were to be arranged, one could contact various resource people in the community. Many times you will find parents in the community who are amateur or even professional astronomers. Such people are often very willing to participate in a field trip. Often a committee from the class can make the necessary contacts with the resource person and plan details of procedure and timing.



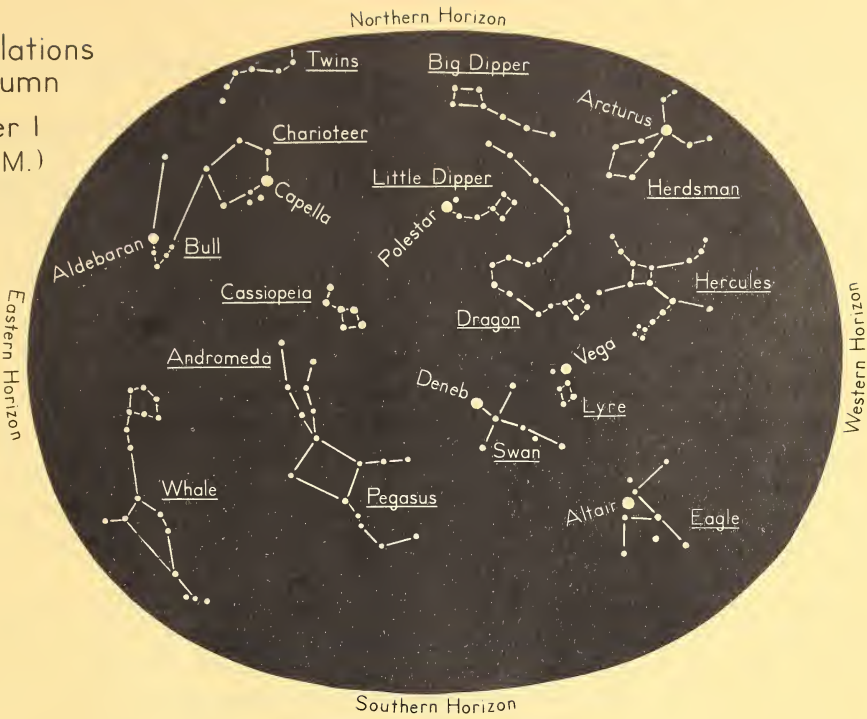
Constellations of Spring (April 1 at 9 P.M.)



Constellations of Summer (July 1 at 9 P.M.)

Constellations of Autumn

(October 1 at 9 P.M.)



Constellations of Winter

(January 1 at 9 P.M.)

In so far as possible, directions for experimentation and demonstrations have been provided. These have been planned to point up particularly pertinent ideas. For example, on page 101 of *Experimenting in Science,* the demonstration with the marbles helps the children to understand why the Milky Way appears to be a blur of light, and why, even with magnification, the stars appear to be close together. This activity has been planned for outdoors. Again, planning is needed and decisions have to be made as to who will take part in the demonstration and how it will be conducted.

In planning, children will probably offer proposals for variations of this demonstration and the other demonstrations in this chapter. Such proposals afford an opportunity for evaluation, and evaluation is, after all, an integral part of the teaching-learning process. The section on evaluation at the end of the chapter offers additional suggestions for evaluation.

A very important part of the experiences in this chapter has to do with discussion by and among the group of children. There are big ideas in this chapter. For example, on pages 102 and 103 the text deals with distances in the sky and the light-year as a unit measure. The child's conception of space is going to be challenged. Through discussion with others he will gradually begin to revise his ideas.

The children can be encouraged to represent their ideas through different art mediums. They might attempt to build models of the solar system, paper replicas of the Galaxy, or they may attempt to picture various star groups. Each activity requires independent research on the part of the individual or group. Opportunities for such independent research are an important part of the children's progress in science. As a culminating activity the individual or committee may report the results of the work to the whole class.

Materials Needed

cardboard
cellophane tape, colored
field glasses, or binoculars
flashlight
marbles, 30
measuring tape
pie plates, 2 glass or Pyrex
pins, common
scissors
shoebox
stones, 12
string

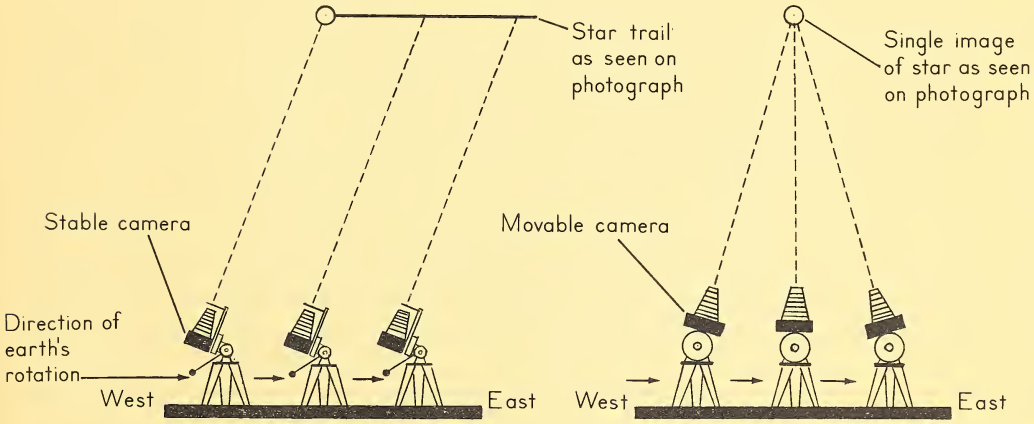
Learning More about the Galaxy

See suggestions for children, page 117, *Experimenting in Science.*

1. Monthly newsletters published by the various planetariums are also very useful in conjunction with observation of the sky. You might have the children contact the planetarium in your vicinity.

2. Trips can be planned as a survey. However, it is much better to have clearly stated purposes and plans for such a trip. In that way, a place may be revisited a number of times. Each trip might very well be with a different objective or purpose in mind.

3. The rotation of the earth on its axis produces the star trails. At observatories the rotation of the earth on its axis is compensated for by having the telescope and camera move gradually in the opposite direction.

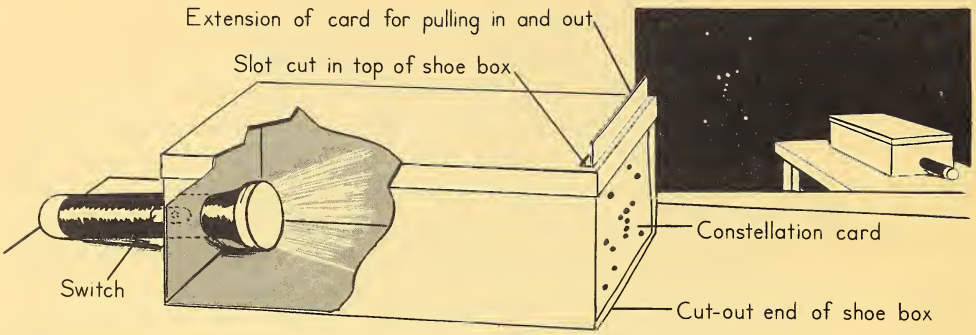


Further Activities

1. Try to locate some planets in the sky. You can often find out when and where to look for them from the newspapers.

2. One or more children might work on a report concerning ancient legends about the stars and constellations. The children will be able to see how our ideas have grown over the centuries.

3. You might have the children picture various star groups. Use a shoe box. Remove one end of the box. Make cards depicting the various constellations. Fit a flashlight in the shoe box and then



place the constellation card over the open end of the shoe box. In the diagram above you can see how this may be done. The constellation can now be projected on a ceiling or wall.

4. Try to find out about some of the instruments astronomers use. The children might make a special report about these instruments. They might report on telescopes, cameras used in astronomical observations, and the spectroscope. Much information can be gathered on such telescopes as those at Mt. Wilson and at Mt. Palomar. The spectroscope is a very special instrument which has been most useful. There is a glass prism in the interior of a spectroscope. Starlight is made to pass through the prism. A great deal can be told about a star on the basis of its spectrum after the starlight has passed through the prism and been broken up into its parts. An astronomer can tell how fast the star is rotating, in which direction through space it is moving, and also what it is made of.

5. The children might give a report on the sizes of various stars in the sky. They can get this information from an encyclopedia and other source books. They will find that our sun is rather an average star. It is not among the biggest nor among the smallest.

Evaluation

The discussion and speculation which this chapter stimulates provides an opportunity for you to make important observations of the children, their concepts, and behavior. The initial free discussion concerning the opening spread can provide you as an observer with an opportunity to make notes concerning the kinds of concepts

with which the children are approaching this chapter. These concepts may be listed so that you will have a convenient check list.

Examine this listing of concepts carefully. A variety of questions might be asked about the list. For example, are there any elements of superstition in the children's concepts relating to space, stars, and the universe? You might find that astrology and its myths are confused with astronomy. The analysis of the concepts may show up other important features of the ideas the children hold.

The study of the chapter *The Milky Way and Beyond* should stimulate noticeable growth in their concepts of stars and the universe. For example, if there are elements of myth and superstition involved in the concepts they hold, as the study progresses, are they willing to reconsider these opinions?

A very important concept contained in this chapter is the vastness of space. As you work with the children, you will begin to see a concept grow. Try to find out about their conceptions of space at the beginning of the study. Discussions and interviews will help you do this. The insights which you will gain as you observe the child's concepts of space being stretched to distances which are practically incomprehensible will aid you in evaluating the growth toward some of the other concepts which have been listed for this chapter in this Manual.

In particular, two questions would seem to be important as you approach the evaluation of a pupil's progress and growth: Is he open-minded? Is he willing to change or revise his concepts as he becomes convinced of the reliability of concepts which differ from his own?

Bibliography

For the Teacher

Bernhard, Hubert J., Bennett, Dorothy A., and Rice, Hugh S. *New Handbook of the Heavens.* McGraw-Hill Book Company, Inc., 1948.

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It,* Chapters 8 and 9. The Dryden Press, 1951.

Burnett, R. Will. *Teaching Science in the Elementary School,* Chapter 12. Rinehart & Company, Inc., 1953.

Craig, Gerald S. *Science for the Elementary-School Teacher,* New Edition, Chapters 7 and 8. Ginn and Company, 1958.

Rey, H. A. *The Stars.* Houghton Mifflin Company, 1952.

For the Children

Cothren, Marion B. *This Is the Moon.* Coward-McCann, Inc., 1946.

Fenton, Carroll Lane and Mildred A. *Worlds in the Sky.* The John Day Company, 1953.

Freeman, Ira and Mae. *Fun with Astronomy.* Random House, Inc., 1953.

Lum, Peter. *The Stars in Our Heaven.* Pantheon Books, Inc., 1948.

Parker, Bertha M. *The Sky above Us.* Row, Peterson and Co., 1953.

Reed, William Maxwell. *Patterns in the Sky.* William Morrow and Company, Inc., 1951.

Rey, Hans A. *Find the Constellations.* Houghton Mifflin Company, 1954.

Schneider, Herman and Nina. *You among the Stars.* William R. Scott, Inc., 1951.

White, Anne Terry. *All about the Stars.* Random House, Inc., 1954.

Williams, Lou. *Dipper Full of Stars.* Follett Publishing Company, 1950.

Wyler, Rose. *The Planet Earth.* Abelard-Schuman, Limited, 1952.

Zim, Herbert S. *Stars: A Guide to the Constellations.* William Morrow and Company, Inc., 1953.

Zim, Herbert S. *The Sun.* William Morrow and Company, Inc., 1953.

Films

DEPTHS OF SPACE. (ISO) 1 reel, b/w. Explores galaxies by means of astronomical photographs from observatories of the United States.

EXPLORING THE UNIVERSE. (EBF) 1 reel, b/w. Demonstrates the principles and construction of telescopes. Shows relationships among the sun, stars, and galaxies. Discusses the theory of the expanding universe.

THE INFINITE UNIVERSE. (ALF) 1 reel, b/w. Shows some of the vast galaxies and distant stars of our universe, and reduces space-time concepts to common everyday dimensions.

MILKY WAY. (ISO) 1 reel, b/w. Shows stars and constellations of the Milky Way Galaxy.

THE MOON. (ISO) 1 reel, b/w. Uses astronomical photography to show the phases of the moon, the craters, polar regions, and other features of the moon's surface.

SOLAR SYSTEM. (ISO) 1 reel, b/w. Illustrates the planets of the solar system, the orbital motion of Venus around the sun; seasonal changes on Mars, close-ups of Saturn, the discovery of Pluto in 1930; and the moons of Jupiter, Uranus, and Neptune.

THE SUN'S FAMILY. (YAF) 1 reel, b/w. Explains what the solar system is.

Filmstrips

CONSTELLATIONS. (SVE) b/w.

EARTH'S SATELLITE—THE MOON. (SVE) b/w.

FUN WITH STARS. (PSP) color.

HOW OUR EARTH BEGAN. (Curr F) color.

How We Think Our Earth Came to Be. (JH) b/w.

Looking at the Stars. (PSP) b/w.

The Sky. (JH) 7 filmstrips, b/w. A Multitude of Suns; Stories of the Constellations; The Sun's Family; Interesting Things about the Planets; Our Neighbor the Moon; The Changing Moon; How We Learn about the Sky.

The Solar System. (YAF) color.

Stars and Galaxies. (SVE) b/w.

The Stars in the Sky. (EGF) color.

The Sun and Its Planets. (SVE) b/w.

What Is in the Sky. (Curr F) color.

VI

Light Energy All around Us

Light is a form of energy. It is with us practically all the time. It surrounds us and makes it possible for us to see and carry on our activities. Without light we would be lost in a black world. In this chapter children are helped to realize both the importance of light and of our ability to produce light when and where we want it. The significance of temperature in the production of light is demonstrated by carefully selected materials.

Science Meanings for Children

No elaborate explanation is necessary to convince us of the importance of light to each and every one of us. The "coming" and "going" of the sun each day are events with which every child is familiar. The "coming" of night and the switching on of the lights are other events with which children are familiar even before they speak. A variety of experiences with light are within the background of each child. The following meanings indicate some of the concepts toward which you may guide the children:

Without light we would not be able to see anything.

Primitive man discovered that he could use the light from a fire.

For many centuries light was produced by the burning of some material.

Heating produces light.

The color of iron changes as it is heated.

Electrons give off energy as light.

Man has discovered many different ways of heating metals.

Electrical energy heats wire as it moves through it. When a metal receives enough heat energy, some of the energy is changed into light.

Our biggest source of light energy is the sun.

The electrons of the heated atoms in the sun give off light energy.

Light energy from the sun comes to us through space, but outer space is black.

Light travels 186,000 miles in one second.

Light energy travels in straight lines.

Light changes direction when it strikes an object.

There is a great variety of color all around us. A beam of sunlight is made up of many different colors of light.

The color of most objects depends upon the light that strikes them.

Information for the Teacher

Light is a form of energy and as with all forms of energy there is movement involved. The moving particles involved in the production of light are electrons.

You will recall that every material is made of atoms. An atom consists usually of at least three kinds of small particles: Electrons, protons, and neutrons. The electrons make up the outer part of the atom. Scientists tell us that the electrons keep revolving rapidly around the center of each atom. You may wish to refer to further material on this subject on pages 13–17 and 122–124 of this Manual.

When a piece of wood is burned or a metal is heated, the atoms of the wood or metal are heated. As the electrons receive more heat energy, they begin moving faster and faster. The more heat the electrons receive, the faster they move. The electrons now have more energy than they had before. The electrons give off this excess energy as light.

Essentially, this principle underlies the experiences discussed on pages 123–126 of *Experimenting in Science*. The burning of materials, such as oil, wax, or gas, to produce light has this basis. However, it should be understood that the production of light by burning took place for many centuries before men had any clear conception of the underlying principle. Early people were able to make use of the fact that heating produced light, even though they had no understanding of how or why. As you will note, the concepts in *Experimenting in Science* leading to the electron theory of light production have been built somewhat on a historical basis; that is, roughly as the concepts evolved through the centuries.

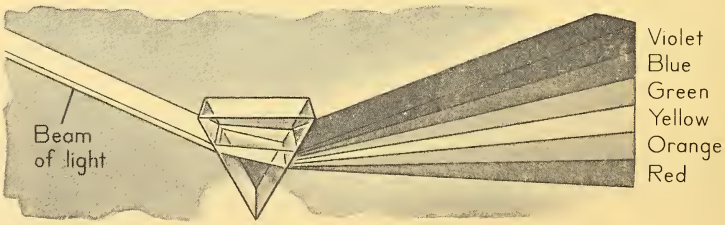
The heating of metals by the use of electrical energy is a rather recent innovation in the long history of light production. Electrical energy changes to heat energy as it moves through a wire. The

atoms of the metal wire become heated. When the electrons of the atoms receive a certain amount of heat energy, they give off light. This is essentially what happens in electric-light bulbs. In an electric-light bulb there is a thin piece of wire made of a metal called tungsten. Electrical energy is sent through the tungsten wire when the light switch is turned on. The tungsten wire becomes heated as the electrical energy moves through it. The atoms of tungsten become heated to a certain temperature, and the electrons of these atoms move faster. The electrons give off this excess energy as light.

The above explanation underlies the explanation on pages 132 and 133 of *Experimenting in Science* of how sunlight is produced. In the sun hydrogen atoms combine to form helium atoms. This change of hydrogen to helium is accompanied by huge explosions. This process is something like that which occurs in a hydrogen bomb. Great amounts of energy are released when these combinations of atoms occur.

There are atoms of many materials in the sun. All the atoms of the sun are heated to very high temperatures by the energy released when hydrogen is changed to helium. The electrons of the heated atoms in the sun give off light just as the electrons of any material here on earth give off light when heated to high temperatures.

Because of the great number and variety of atoms being heated simultaneously on the sun, sunlight, or what we call white light, is really a mixture of different colors. You can use a glass prism or a piece of cut glass to show the spectrum. On page 140 of *Experimenting in Science* and in the diagram below the spectrum colors are listed: violet, blue, green, yellow, orange, and red. You will note that indigo is not included in these lists. Indigo as a description of a spectrum color has become an obsolete term. In addition, it is difficult for children to distinguish such a color from the varying hues of violet and blue. As you view the spectrum with children, one of the



most obvious points to bring out is that there is no sharp dividing line between the colors. But there are varying hues of each color, and one color blends gradually into the next: violet into blue, blue into green, green into yellow, and so on.

An object is seen as white because all the different colors are reflected to our eyes when white light falls on such an object. However, many objects do appear colored when seen in white light. When an object appears green, it reflects only the green to our eyes. The violet, blue, yellow, orange, and red (the other five colors which make up white light) are not reflected back to our eyes.

When we mix two colors of paints, we sometimes get a third color. For example, blue and yellow paints when mixed often give green. This is because some kinds of coloring materials, called pigments, reflect two colors. They reflect more of one of the colors than they do of the other. The yellow pigment reflects mostly yellow and some green; the blue mostly blue and some green. When mixed together, green is the only color neither will absorb, and hence it is the color reflected.

Ways of Working with Children

The opening spread of this chapter is a good stimulant to discussion. As you will note, the emphasis in the first part of *Light Energy All around Us* is on discussion. Here is something, light, with which the child has been surrounded all his life. The point of departure is to re-examine the familiar. The absence of light with all its connotations can lead to interesting speculation. Through such discussion you can also get an idea of the concepts the children have as well as the process by which they are arriving at some of their concepts. Who or what do they accept as an authority? On what do they base their speculation? Do they begin to revise their conceptions during a discussion?

As the discussion progresses, there are simple checks and experiences which should be elicited from the group. For example, a discussion of a completely dark place could be interrupted for a short trip to a dark closet or storage room as suggested on page 119 of *Experimenting in Science*. Take time to explore and talk over the points that arise. Some children who discussed this material brought bats into their discussion. This point stimulated others to explore

material about "night-fighters," the use of radar to track targets, and the whole principle of "blind-flying." Out of such discussion can come many individual interests which serve as the basis for individual reports and pupil forums. This type of activity can greatly enrich the learning of the whole group.

In this chapter, as well as in all other chapters, special provision has been made for pupil experimentation. The text provides many simple experiences that may be undertaken by the children. All the materials are easily procurable. Time should be provided within the classroom for the undertaking of these demonstrations and experiments by the children.

The brief historical treatment on pages 121 and 122 of the text can provide material and ideas from which a mural may be made. You might also encourage the children to do further research and add to their mural. They could depict man's use and production of light through the ages.

On page 124 the discussion centers around a blacksmith. You might know of a blacksmith in your community or in another community close by. A visit to his shop would be very worth while. As part of the planning for such a trip there would need to be additional research done. The group should have a definite purpose and should be prepared to ask specific questions. Many communities have iron works, steel mills, and small shops which form iron into railings and fences for homes. A trip planned properly for a specific purpose to any of these places would provide much firsthand information.

Encourage the children to look about them and suggest variations of the experiments in the text. For example, the experiments dealing with color might be varied by using paint pigments. The mixing of various pigments will give new colors. As you will recall, material dealing with this has been provided in the section *Information for the Teacher*. Such variations will stimulate the children to search for explanations and to apply the principles illustrated and developed in the body of the text.

The suggestion on page 131 of *Experimenting in Science* that the children make a list of ways in which sunlight is valuable can be made quite challenging. Ask the children to describe how different specific things would be if there were no sunlight. As the descriptions are made, various statements should be challenged with such questions as, "Why would that come about?" Compiling this list will

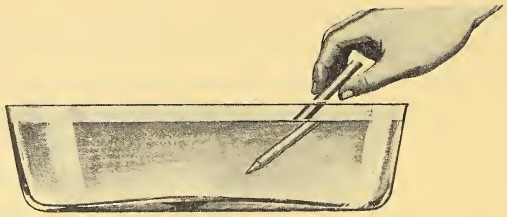
help the children recall and put to use in a new context the information in the first five chapters of *Experimenting in Science*. This kind of discussion provides for a review as well as an evaluation of the way previous information is put to use. This should not be hurried, and the children may even want to recheck some of their information by rereading portions of the first five chapters.

On page 137 of the text the experiment suggested calls for reconstruction of a hallway. The materials, of course, are easily obtainable. However, the experimentation need not be confined to this reconstruction. The children might be encouraged to work as teams or individuals and to seek out hallways at home and other places. They could perform variations of these experiments in these hallways and report their findings to the group. Part of their report could incorporate a diagram of the hallways.

On page 141 of *Experimenting in Science* the experiment deals with the problem of where colors come from. A very simple variation of such an experiment can be worked out. Have the children assemble pieces of cloth or other materials. They should get six pieces in all: violet, blue, green, yellow, orange, and red. Look at the violet cloth in sunlight and then look at it under an electric light. Have the children describe what, if any, is the color change. Repeat this for each color with the same electric light. The slight changes in color will be due to the difference in the color emitted by the electric light as compared with sunlight.

Materials Needed

candle
cardboard, including 2 pieces each 12 inches square
cellophane, red
cork
crayon, green
dry cell, No. 6
electric-light bulbs
flashlight
mirrors, pocket
needle
pan
paper, heavy colored
pencil
prism, or piece of cut glass
shoe boxes, 3
sockets, for electric-light bulbs
tumbler, glass
water
wire, insulated copper and iron



Learning More about Light

See suggestions for children, page 143, *Experimenting in Science.*

1. Light is bent as it passes from one medium to another. The pencil will appear to be broken because of the bending of the light as it enters the water.

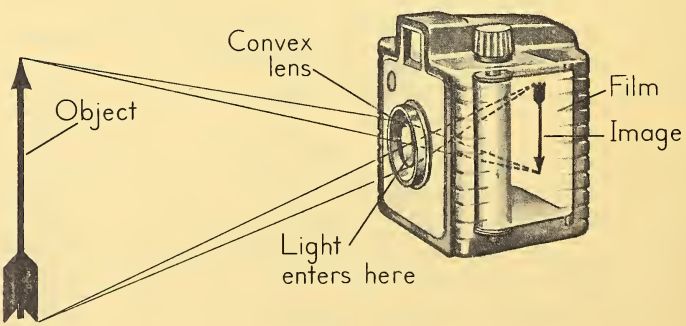
2. Prisms do not need to be made of glass. A droplet of water under certain circumstances may also act to bend and reflect light. In certain cases this gives rise to the rainbow in the sky as well as the rainbow seen in the spray of a lawn sprinkler or a waterfall.

3. The material placed behind the glass does not let the light pass through. And so the glass reflects the light back to you, and you can see your image.

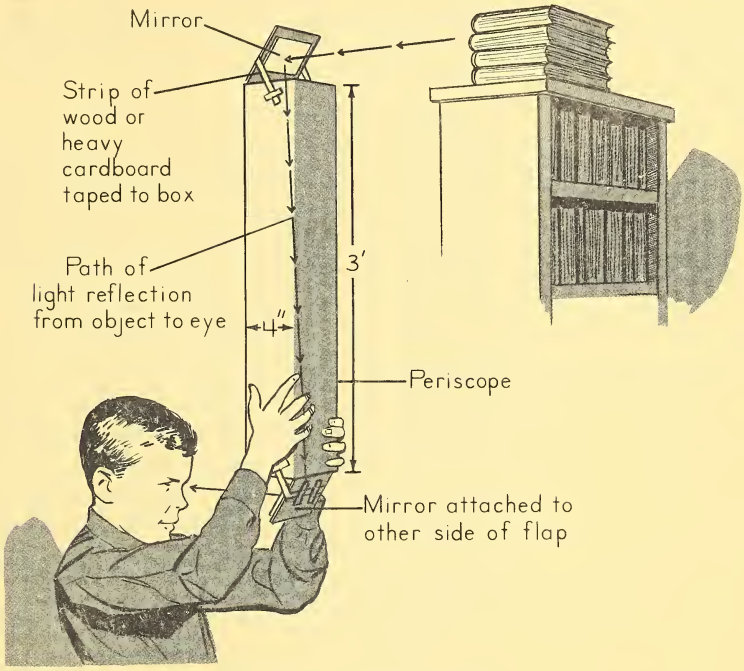
4. The artificial light is deficient in blue.

Further Activities

1. A group might like to make a study of the camera and report to the class how it works. How does light affect the film? Perhaps you can get a professional photographer to come and talk to your group. He will be able to tell you a lot about the effects of light on film.



2. The children can make a periscope. Construct a long rectangular tube 3 feet long by 4 inches wide. Place mirrors at an angle at the top and bottom of the tube as you see in the picture below. The periscope works on the principle of reflection. The light is reflected down the tube in a straight line by the mirror at the top. Then the light is reflected to your eye by the mirror at the bottom.


Mirror
Strip of wood or heavy cardboard taped to box
Path of light reflection from object to eye
3'
4"
Periscope
Mirror attached to other side of flap

3. Have the children make a list of things that give off their own light. These are called sources of light.

4. Many animals give off light. These lights are probably produced by chemicals in the animals' body. You might do some research on the various animals that give off light. You might look up the following animals: the firefly, glowworm, and jellyfish.

5. Have you ever thought what the world would be like if nothing reflected light? Ask the children to try to describe what it would be like in the room you are in now. What would it be like outside when the sun is shining?

Evaluation

You should be seeing and hearing the effects of this body of content upon the children all through the activities and discussions which take place in connection with the chapter. There are many provocative ideas and concepts that should affect the way they look at their physical environment. Concepts relating to the production of sunlight and the traveling of light energy through outer space without lighting it up stretch and stimulate the imagination. These concepts cannot help but bubble over into interesting discussions. It is during such discussions that the teacher can truly get the best insights into how the children have increased their understandings, appreciations, and attitudes. These, after all, should be the goals rather than the number of facts they can recall.

Many of the concepts relating to light energy cannot be checked or even attempted by the children. However, these concepts come within their realm of experience and contacts. In their discussions who or what do they accept as an authority on which to base their concepts? How do they go about checking to see if the source of their information is reliable? This is a very important point. Throughout life many of their discussions will be based upon information received from various sources. Is the source reliable? "Can I rely on this information?" should be a question that is uppermost and which the children should have before them constantly. The teacher can encourage and foster this attitude in the children by questions beginning with "How do you know—"

An attempt should be made to pose questions for the children or raise problems for discussion which will stimulate them to apply the information they have acquired. The question in the center heading on page 123 of *Experimenting in Science* is of this type. What *is* light? Further questions may be framed around the listing of science meanings in the beginning of this chapter in this Manual. Questions of this type might also be elicited from the children. Time might be taken to formulate questions for a round-table discussion or forum. This would stimulate the children to do additional research to prepare for their part in such a forum. The quality of the presentation during the forum will also provide additional clues to the individual's growth in the content area and the concomitant growth in his ability to present his ideas.

Bibliography

For the Teacher

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It*, Chapter 23. The Dryden Press, 1951.

Craig, Gerald S. *Science for the Elementary-School Teacher*, New Edition, Chapter 24. Ginn and Company, 1958.

Parker, Bertha M. *Science Experiences.* Row, Peterson and Co., 1952.

Rowland, John. *Atoms Work Like This.* Roy Publishers, 1956.

Yates, Raymond Francis. *Atomic Experiments for Boys.* Harper & Brothers, 1952.

For the Children

Adler, Irving. *Fire in Your Life.* The John Day Company, 1955.

Bendick, Jeanne. *Electronics for Young People.* McGraw-Hill Book Company, Inc., 1955.

Bischof, George P. *Atoms at Work.* Harcourt, Brace and Company, 1951.

Epstein, Samuel and Beryl W. *First Book of Electricity.* Franklin Watts, Inc., 1953.

Hyde, Margaret O. *Atoms Today and Tomorrow.* McGraw-Hill Book Company, Inc., 1955.

Meyer, Jerome Sydney. *Picture Book of Electricity.* Lothrop, Lee & Shepard Company, Inc., 1953.

Parker, Bertha M. *Light.* Row, Peterson and Co., 1949.

Potter, Robert Ducharme. *Young People's Book of Atomic Energy.* Dodd, Mead & Company, Inc., 1952.

Sears, Paul McCutcheon. *Firefly.* Holiday House, 1956.

Zim, Herbert S. *Lightning and Thunder.* William Morrow and Company Inc., 1952.

Zim, Herbert S. *The Sun.* William Morrow and Company, Inc., 1953.

Films

FIRE. (EBF) 1 reel, b/w. Describes the domestic use of fire and clearly explains the principles of combustion.

HOW MAN MADE DAY. (Cor) 1 reel, b/w & color. Traces the development of illumination from primitive to modern times.

LEARNING ABOUT LIGHT. (EBF) 1 reel, b/w. Demonstrates by animation and live action various introductory concepts relating to light.

LIGHT ALL ABOUT US. (Cor) 1 reel, b/w & color. Demonstrates that we see only when there is light and that everything will reflect light.

LIGHT AND SHADOW. (YAF) 1 reel, b/w. Presents introductory concepts about the nature and behavior of light. Discusses transmission and reflection of light rays, and luminous, transparent, translucent, and opaque objects.

THINGS EXPAND WHEN HEATED. (YAF) 1 reel, b/w. Demonstrates by animation and simple photography the movements of molecules before and after heat is applied.

WE MAKE A FIRE. (IF) 1 reel, b/w. Develops an understanding of factors involved in making a fire burn.

Filmstrips

ELECTRICITY. (SVE) b/w.

ELECTRICITY. (YAF) b/w.

HOW HEAT IS TRANSFERRED. (YAF) color.

LIGHT. (EBF) color.

LIGHT. (YAF) color.

LIGHT IN OUR DAILY LIVES. (EGF) color.

WE MAKE A FIRE. (EBF) b/w.

THE WONDER OF THE ELECTRIC LIGHT. (EGF) color.

VII

Plants and Animals Live in Communities

The community idea, which embraces the interdependence of plants, animals, and the physical environment, forms the basis of this chapter. Plants and animals live in characteristic communities. In this chapter the major principles affecting communities are discussed and illustrated through many unique experiments.

Science Meanings for Children

Eleven- and twelve-year-olds know that to catch a fish they must go to a pond or some other body of water. They may be less familiar with the fact that to pick a daisy they would have to go to a meadow and not deep into the forest. And then again, each child in your class would probably know that cactus grows best in an arid region. There will be some information and experience in the group concerning plants and animals. The meanings that follow will help the children understand and appreciate the interdependence of plants and animals and the distribution of their communities:

A community usually has green plants.

Green plants need energy from the sun to produce the plant material which animals use as food.

Chemicals are a part of the community, too.

Water and carbon dioxide are important chemicals in any community.

Without a continual supply of oxygen no animal would be able to live.

Most of the energy reaching our earth and its many communities comes as light energy.

Light energy is changed by plants to chemical energy.

Changes in the energy supply of a community affect the whole community.

The amount of water falling on a community affects the kinds of plants and animals living in the community.

Communities continually change.
Man affects communities.

Information for the Teacher

Communities consist of plants, animals, chemicals, and energy from the sun. Each is a vital part of the community. The make-up and appearance of the community depend on the amount of these factors and the balance among them.

The food-making activity of plants makes it possible for all animals to exist. A description of the process of photosynthesis, or food-making, by plants is given in the section *Information for the Teacher* on pages 41–42 of this Manual. You may want to refer to this again at this time.

Animals depend either directly or indirectly upon green plants, since these plants manufacture food. This places a limit on the number of animals which can live successfully in any community. If there are too many animals, they may devour too many or all of the plants. A shortage of food will develop in that community and many of the animals will die of starvation. The plant life also determines to a major extent the kinds of animals found in a community. For example, grasshoppers feed largely on grass plants. Therefore you can expect grasshoppers to be abundant in a meadow, but very scarce in a pine forest. A natural check on the number of animals in the community is the fact that each species of animal has its enemies. For example, the rabbit is a vegetarian feeding only on plants, but the fox will feed upon the rabbit.

Many times man tampers with the natural balance in a community without fully understanding the consequences. A classic example of such unintelligent tampering was the introduction of rabbits into Australia. The rabbit was not a natural member of the Australian community. Thus in Australia the rabbit had no natural enemies. Rabbits in Australia multiplied. They fed upon the grasses and actually competed with the sheep for the grass plants. Even though vigorous extermination campaigns have been waged against rabbits in Australia, they are still a tremendous problem to sheep raisers and the wool industry.

Water is an essential in every community. There may be an abundance or scarcity of water, but one thing is certain—there must

be water. Many substances are dissolved in water. This solvent property of water is very important.

Large bodies of water act as stabilizers. Water is a storage place for heat energy. The experiment on pages 149–150 of *Experimenting in Science* illustrates this point; that is, that water warms slowly and cools slowly and thus loses its heat energy less rapidly than many other substances. The temperature of water does not fluctuate as rapidly as soil. This property of water has a decided effect on the living things which exist near and in the water.

The maps on pages 152 and 155 of the text are very important. They point up the fact that the amount of precipitation a region receives depends on its location. This in turn affects the communities in the region. This section is based on the principle that cool air holds less moisture than warm air. Topographical features, such as mountains, bring about the cooling of air as it is forced up and over the mountains. Warm, moist air is also cooled when it is forced up over a cold air mass. Such a situation is depicted on page 156 of *Experimenting in Science.*

A pond is an excellent community to study. The plants and animals described on pages 157–159 of *Experimenting in Science* will not all be found in any one pond, but you may find some of them in ponds in your region.

Ponds, of course, will vary. Changing weather conditions will bring about noticeable changes in the balance of a pond over short periods. When this happens, it is very good for the purposes of short-range observation. In early summer a pond may contain many of the plants and animals discussed on pages 157–159 of *Experimenting in Science.* But an extremely dry summer will gradually bring about changes. The pond may begin to dry up slowly as the water evaporates. The area of the pond becomes smaller. The animals have less room and are more crowded. Because of the shrinking area of the pond there is less oxygen available in the water for them to use. The animals give off carbon dioxide. The decrease in plant life and water volume brings about an acid condition as the carbon dioxide combines with the water to form carbonic acid. A change in the acidity of the water may kill some of the algae and affect the other plants too. Frogs and turtles will begin to leave the pond area as it dries up. The insects may become more numerous when this happens, because frogs and turtles normally eat insects.

Ways of Working with Children

The initial discussion may begin with consideration of the community idea. It may be centered on the material in the opening spread of this chapter on pages 144–145 of *Experimenting in Science.* However, it would be very beneficial to go out for a short stroll around the school. Observe some of the types of plant-and-animal communities which can be found in the immediate vicinity of the school. This trip need not be extensive, merely a brief survey. Future plans for more extensive exploration can then be developed on the basis of this survey. A record may be kept of the things noted on this trip. It is also a good idea to make a note of the location of the various items. This can be done by a written description of the location, or the location may be noted on a map, which the children can construct, of the area immediately around the school.

On pages 146–150 of *Experimenting in Science* some basic principles relating to communities are developed. The experiment dealing with temperature and temperature changes can be done a number of times. The record can be kept for a week or for a

Wahl-Coats Elementary School, Greenville, North Carolina. J. D. Henry

These children are studying temperature changes in sand, barren black soil, grass-covered soil, and water.

month or even longer. The keeping of the record and the noting of the temperatures at specific times during the day need not occupy very much time at all. In fact, a committee of two or three children may want to assume responsibility for the project. As the data accumulates, the children may try to analyze the way the variations in temperature occur. They may even try to predict what the temperature variation will be for each of the containers on the basis of the predicted weather report for the next day.

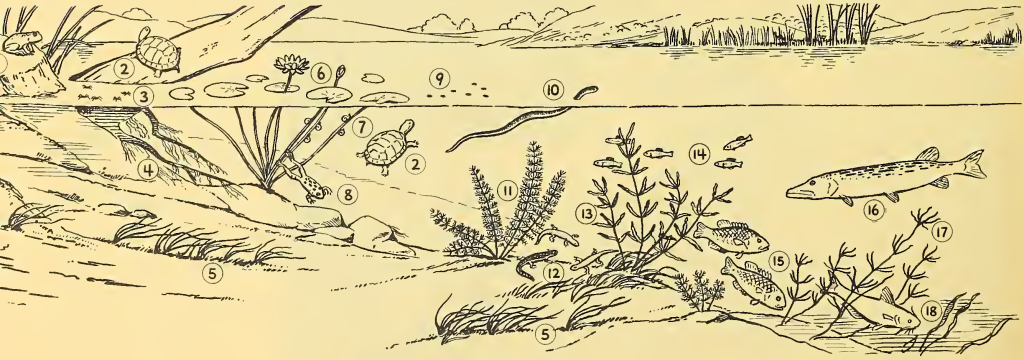
On pages 151–154 of the text an attempt is made to give an overview of the general types of plant-and-animal communities into which the United States and Canada can be divided. Much of this treatment is developed on the basis of surface features and available water. During the study of this section it will be helpful to have a large map of the North American continent available. A project which the class or members of the group may wish to undertake is the construction of a relief map of the North American continent. This can be done on a sand table or other large flat surface. The group can fill in important features such as mountain areas, water areas, forest areas, desert areas, grassland areas, and huge urban concentrations. This can be done with clay, papier-maché, or other suitable construction material. It can be as extensive and detailed as the group wishes. The more extensive and detailed, the greater will be the need for research on the part of the children. They will be able to trace on their map the descriptions of wind and air movements contained in the text. A photograph of children working on such a project is shown on page 5 of this Manual.

Another project which can grow out of the map construction is the keeping of weather records for various areas of the country. These records should include the amount of rainfall and other forms of precipitation falling on the area. If these records are kept over a long period of time—for the whole year if possible—the children will see the accumulation of precipitation for each area. Again, this is a project which need not engage the whole class. Rather, a few children can keep the records and give progress reports to the whole group at specific intervals. Their information can be gathered from television, radio, and newspaper reports.

Newspapers are good sources of information. You can often find reports of conservation measures which point up the interdependence of plants, animals, and the physical environment. For

example, on page 56 of the *New York Times* magazine section for Sunday, April 22, 1955 there appeared an article dealing with the fact that beavers are being parachuted to various regions, for the nation's benefit. Conservation men trap beavers where they are not wanted and move them to places where their dams will do some good. The story relates how beavers seek water and build a dam to create a pond in which to put up a home. Two beavers using trees, stones, reeds, and mud can finish a dam 18 feet long and 6 feet wide in about three weeks. The water-distributing which results can be beneficial to the country for miles around. The article furnishes information about how beavers saved thousands of acres from erosion in the Northwest. Despite heavy drought healthy foliage was kept growing in Palisades Interstate Park in New Jersey due to beaver activity. Other effects, such as raising the level of water in lakes near Winnipeg as much as 3 feet, are also indicated in the article. Reports such as this of current practices can provide a basis for stimulating discussion and point up the application of the principles to national problems.

On page 157 of *Experimenting in Science* the study of a pond community is traced in some detail. The key below to the illustration on pages 158–159 of the text is included for your interest. It is not intended that the identification of those plants and animals be part of



1. Toad
2. Turtle
3. Water striders
4. Algae
5. Wild celery
6. Lily pads
7. Water snails
8. Frog
9. Whirligig beetles
10. Water snake
11. Milfoil
12. Salamander
13. Naiads
14. Top minnows
15. Bass
16. Pike
17. Pondweed
18. Catfish

your teaching. However, the key may be helpful to you should questions arise. It may also be of assistance should any individual be interested in undertaking further research on the subject of pond communities.

It would be worth while to observe the kind of life found in other water communities, too. A lake, stream, or ocean shore provides good opportunities to study plant-and-animal communities adapted to particular conditions. You may wish at this time to refer again to the text and illustrations on page 96 of *Experimenting in Science.* The problems faced by animals during difficult periods can be a point of departure for a discussion of changes in a community.

Land communities of different types are probably more readily accessible than pond communities. A great variety may be found in a small area. A meadow, woods, swamp, and pasture may all be within a short walking distance of each other. Compare the plants and animals found in each community with the others. In cities one can go to a vacant lot, a hillside, a park area, and the school ground.

Opportunities for the study of various plant-and-animal communities can be provided in the classroom. A very profitable and interesting experience is the setting up of an aquarium. A gallon pickle jar or mayonnaise jar may be used as the container. Detailed directions for setting up such a freshwater community can be found on pages 491–495 of *Science for the Elementary-School Teacher,* New Edition, by Gerald S. Craig.

Conditions found out-of-doors in various land communities can be reproduced by children in the classroom. A terrarium can be used to carry out further study in the classroom. A hillside, a swamp, a desert, a wooded area, a field, all may be reproduced and studied. Directions for constructing a good terrarium container from ordinary window glass may be found on pages 495–497 of *Science for the Elementary-School Teacher,* New Edition.

Materials Needed

boxes, 2
grass-covered soil
ice
pail, large
sand
seeds, clover
soil
thermometers, 3 outdoor
tumblers, 2 glass or aluminum
water, both hot and cold

Learning More

See suggestions for children, page 163, *Experimenting in Science.*

1. Some changes are: changes in leaf color, falling of leaves, hibernation of some animals, migration of others. Water availability usually decreases. Availability of food for animals usually decreases.

2. These depend on the section of soil you happen to dig into.

3. The answers to these questions depend on the conditions and particular time at which the record is made.

4. The answers depend on the animals observed by the children in your community.

5. Yes, the log forms a little community.

Further Activities

1. What plants and animals provide us with our most important foods? What special types of conditions does man supply to help these plants and animals? Man really sets up special communities for them. He finds out the conditions under which they grow best and then he attempts to meet all these conditions. Several children might each choose one plant and one animal and describe the conditions under which each grows best.

2. Search out spots in which mushrooms grow. You will probably find them growing after a period of damp, warm weather. How do mushrooms get their food? You will notice that they do not contain chlorophyll, the green coloring matter so necessary for plants to manufacture food. You might have the children do further reading on mushrooms in the encyclopedia and other source books and report their findings to the class. The material on page 63 of *Experimenting in Science* might be reviewed at this time.

3. Plant some clover. After it is fully grown, carefully dig up a plant. You will find little knobs, or nodules, on the roots. These nodules contain bacteria that make nitrogen compounds. These bacteria are an important part of the community. A group might look up some more information on nitrogen-fixing bacteria and give a report to the class on this topic. There is further information on nitrogen-fixing bacteria on pages 108–109 of this Manual.

4. The children might make a list of various ways in which plants and animals help each other in a community.

5. How has man affected plant-and-animal communities in the

past? How did the early pioneers affect the plant-and-animal communities in North America? A group might look up some of the early history of North America, especially the descriptions of the great virgin forests which covered eastern North America.

6. Elephants, prairie dogs, beavers are all examples of social animals. You might have the children look up information on these animals to see how they help each other by living together.

Evaluation

The underlying purpose of *Plants and Animals Live in Communities* is to give children a feeling for the interdependence of plants, animals, and the physical environment. Sometimes it is helpful to have the children make a list of their learnings. The list may include many of the science meanings on pages 93–94 at the beginning of this chapter in this Manual. But one should not expect all these meanings to appear in such a list. The activities engaged in by the children have undoubtedly been varied. Any list compiled by individual children or a group of children will show this variety of activity. Certain facets of the experiences will mean more to one child than another. This will be reflected in the list compiled.

The way such a list is arrived at is important. It too forms a part of the evaluation. It might be worth while to have the children form small groups of four or five and prepare lists of some important things they did and learned during the study of the chapter. This would provide possibly six or seven lists for the class as a whole. These lists then could provide a basis for discussion with the whole class. Comparisons could be made among the lists, and children could be helped to see the principles behind the items on the various lists. After discussion and comparison of the lists, the children might be helped to formulate a single, more generalized list.

Through discussion you may try to ascertain how much the children have learned about the various key regions of the United States and Canada. Do they see that the rainfall, plants, and animals of these regions are a reflection of the physical topography and location of these regions? Encourage the children to project their ideas concerning how man may put his understanding of community balance to work for him.

Through all the activities and discussions, watch for evidence that

children are growing in their ability to do critical thinking. The principles developed in this chapter are basic to many of the issues on which they may have to vote as citizens. We cannot hope to provide the answers, but we can go a long way by encouraging children to be original and critical in thought and observation. It is for this reason that the activities on page 163 of *Experimenting in Science* have been so constructed. An element of discovery and true exploration is involved. How do the children approach such activities? Remember that good teaching is heavily weighted on the side of helping children have meaningful experiences from which they may learn. How well have the children carried out the activities? Do they learn from such experiences? What do they learn? How do they bring the content that they have acquired to bear on such activities?

Bibliography

For the Teacher

Andrews, Roy Chapman. *Nature's Ways.* Crown Publishers, 1951.

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It,* Chapter 13. The Dryden Press, 1951.

Craig, Gerald S. *Science for the Elementary-School Teacher,* New Edition, Chapter 14 and also Chapter 21 (pages 641–652). Ginn and Company, 1958.

For the Children

Berrill, Jacquelyn. *Wonders of the Seashore.* Dodd, Mead & Company, Inc., 1951.

Blough, Glenn O. *Not Only for Ducks: The Story of Rain.* McGraw-Hill Book Company, Inc., 1954.

Bridges, William. *Zoo Expeditions.* William Morrow and Company, Inc., 1954.

Buck, Margaret Waring. *In Ponds and Streams.* Abingdon Press, 1955.

Bullough, William Sydney and Helena. *Introducing Animals-with-Backbones.* Thomas Y. Crowell Company, 1954.

Earle, Olive Lydia. *Swans of Willow Pond.* William Morrow and Company, Inc., 1955.

Fenton, Carroll Lane, and Pallas, Dorothy Constance. *Birds and Their World.* The John Day Company, 1954.

George, John L. and Jean C. *Bubo, the Great Horned Owl.* E. P. Dutton & Co., Inc., 1954.

Huntington, Harriet E. *Let's Go to the Brook.* Doubleday & Company, Inc., 1952.

Huntington, Harriet E. *Let's Go to the Desert.* Doubleday & Company, Inc., 1949.

McClung, Robert M. *Bufo: Story of a Toad.* William Morrow and Company, Inc., 1954.

Pels, Gertrude J. *Care of Water Pets.* Thomas Y. Crowell Company, 1955.

Robertson, Gladys Vondy, and Graham, Vera M. *Strange Sea Life.* Henry Holt and Company, Inc., 1950.

Sears, Paul McCutcheon. *Tree Frog.* Holiday House, 1954.

Selsam, Millicent. *See through the Forest.* Harper & Brothers, 1956.

Spilhaus, Athelstan Frederick. *Weathercraft.* The Viking Press, 1951.

Sterling, Dorothy. *Insects and the Homes They Build.* Doubleday & Company, Inc., 1954.

Tannehill, Ivan R. *All about the Weather.* Random House, Inc., 1953.

Van Dersal, William R., and Graham, Edward H. *Wildlife for America* Oxford University Press, Inc., 1949.

White, Anne Terry. *Prehistoric America.* Random House, Inc., 1951.

Films

CHAIN OF LIFE. (PFC) 1 reel, color. Shows food chains which link together all living things in a community.

CHAPARRAL—THE ELFIN FOREST. (Barr) 1½ reels, color. Shows the interdependence of plant and animal life in a forest in the foothills of the Pacific Southwest.

COCO EXPLORES A PIER. (RP) 1 reel, color. Pictures barnacles and mussels, and shows how seaweeds differ from land plants.

LIFE IN A GARDEN. (McGH) 1 reel, b/w & color. Shows how various kinds of animals survive in a natural habitat with each other. (Produced by American Museum of Natural History, New York.)

LIFE IN THE GRASSLAND. (EBF) 1 reel, b/w & color. Shows community relationships of plants and animals.

LIFE IN A WHEAT FIELD. (ALF) 1 reel, b/w. Shows animals that live in a wheat field and the interrelationships involved.

PONDS. (ALF) 1 reel, b/w & color. The camera exposes the underwater wonderworld—from primitive protozoans to complex marine creatures. Includes hydra, snails, dragonflies, water beetles, crayfish, pike, salamanders, and turtles.

SECRETS OF THE POND. (ALF) 1 reel, b/w. Shows the variety of plant life inhabiting a country pond.

SEEDS OF DESTRUCTION. (EBF) 1 reel, color. A pictured statement of what happens when any one of the links in the "chain of life" is broken.

SUMMER MEADOWS. (ALF) 1 reel, b/w. Shows a variety of plant and animal life in a meadow in summertime.

THIS VITAL EARTH. (EBF) 1 reel, color. Tells the story of plant and animal ecology—the relation of life to its environment.

WHAT MAKES RAIN? (YAF) 1 reel, b/w. Presents and amplifies the concept of the water cycle and the evaporation and condensation of water.

Filmstrips

Animal Environments. (Curr F) 8 filmstrips, color: How Animals Live in the Arctic, the Air, the Desert, the Forest, Fresh Water, the Grasslands, the Sea, and the Swamps.

Animals Fit Themselves to Their Surroundings. (EGF) color.

Animals Struggle to Live. (EGF) color.

The Behavior of Plants. (Curr F) color.

The Behavior of Simple Animals. (Curr F) color.

Desert Animal Life. (PDP) color.

Desert Plant Life. (PDP) color.

How Living Things Respond. (Curr F) color.

Life in Ponds, Lakes, and Streams. (JH) color.

Life on the Desert. (SVE) b/w.

Plants and Animals in Their Natural Environments. (SVE) 4 filmstrips, color: Plants and Animals of the Mountain, of the Desert, of Swamps and Marshes, and under the Sea.

VIII

Using Water, Soil, and Forests Wisely

This chapter takes a look at three important resources: water, soil, and forests. It attempts to develop some basic principles which underlie the wise and most beneficial use of these resources. A critical look is taken at some of the problems and solutions which have arisen in connection with man's use of water, soil, and forests. Man's needs and responsibilities are emphasized.

Science Meanings for Children

We are surely in need of intelligent action with respect to the conservation of our resources. This action must be based on the best information available. Conservation must become a part of the behavior of everyone. Each child by his actions and behavior can become a potent force in the conservation of our resources. The concepts that follow underlie many valuable conservation practices:

When rain falls on a steep, bare slope, much of the water runs off and carries part of the soil with it.

Plants allow falling water to soak slowly into the soil.

Contour trenches on bare slopes catch and hold the water from rain and melting snow.

Check dams are a useful initial way of preventing runoff and repairing gully erosion.

Grasses, shrubs, or trees should be planted on bare slopes and in gullies.

Roots of plants hold soil and prevent it from washing away.

Each of us needs water to live. We use and need a great deal of water to grow our food and run our factories.

Our best sources of water are rain and snow.

Water evaporates from the ground and plants.

Water runoff flows into lakes, rivers, and oceans. Some water sinks into the ground and becomes part of the ground water.

Dams hold back water and prevent floods. The energy of the falling water at a dam can be used to produce electricity.

Plants need good soil in which to grow.

Topsoil is a long time in the making. It is the part of the soil in which plants grow.

Topsoil contains mineral elements. When topsoil is lost, important minerals are lost.

Careful planning must be done to keep the land producing good crops. Contour-plowing and strip-cropping are farming practices which help conserve the land.

The forests of the earth help to enrich our soil and to control our water supply.

We use a great deal of wood and products made from wood.

Trees are one of our most important crops.

Trees will grow on land which is not well suited to other crops.

Information for the Teacher

This chapter is really concerned with conservation practices. Three major areas are selected for discussion: water, soil, and forests. The essential interrelatedness of these three factors is stressed throughout the development.

Conservation does not mean hoarding. The emphasis in this chapter is on wise use. We must use our soil, our water, and our trees. Wise use can mean a fuller, more abundant use.

The United States and Canada originally had an abundance of good soil. In many parts of the continent much of the good soil has been dissipated through improper use. The improper use has included faulty agricultural practices and methods, clearing of forest land, overgrazing, and the use of marginal lands.

Erosion is a process that will probably always be with us. Wind blowing over the land and water falling on the land will pick up soil and move it from place to place. However, man can control the process of erosion and by simple methods prevent it from getting out of hand. A good, thick cover of plant material on the land holds the soil in place. Wind erosion is thus kept to a minimum. Water erosion is also controlled by plant cover. Plants hold back falling water. They allow it to soak slowly into the soil.

Forest areas are good controllers of erosion. Falling rain strikes the branches, leaves, and trunks of the trees. The force of impact

is thus broken; the water does not beat against the ground. The ground beneath the trees is covered with a thick mat of dead leaves, twigs, and other plant material. The soil beneath this layer is soft and spongy. Water has an excellent opportunity to sink into the ground in a forested area during a rainfall.

When the plant cover must be removed so that the soil may be used for farm land, certain practices will minimize erosion. In contour-farming, land is plowed on the level along the slope of the land. This prevents water from running off the land. The water is held in place and has an opportunity to soak into the ground. Another practice which checks erosion is strip-cropping. Strips of close-growing grass crops, such as wheat, are alternated with strips of a different type of crop. The grass crop will be harvested at a different time from the alternating crop. Thus there will be a continuous plant cover for the soil, and water runoff will be checked.

A practice which has not been used to any great extent in this country is terracing of land. Many of the early Indian cultures of South America used a method of terracing to prevent the erosion of hilly land. Variations of this method are also used in many parts of Europe and Asia. The abundance of good land and the expense involved have been two factors which have worked against the terracing of land in the United States and Canada.

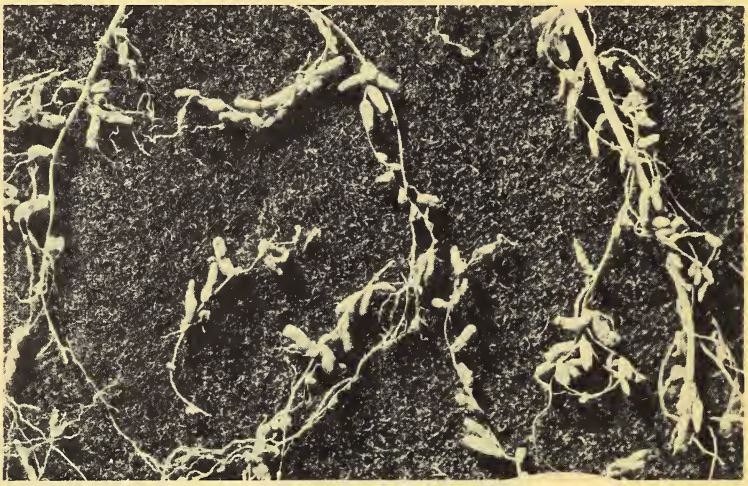
Topsoil contains certain mineral elements. Of these elements

Grace Line Photo

These terraces were made long ago by the Inca Indians in the Andean highlands of Peru.

nitrogen is probably the most important. Crops will not grow well if there is not a sufficient quantity of nitrogen in the soil. In the natural cycle, decaying animal and plant material in the soil replenishes the nitrogen in a form which can be used by plants. This decaying material is usually referred to as humus. It is an important part of soil. However, the faster and more usual method of replenishing nitrogen and the other important mineral elements is by commercial fertilizer.

An effective way of conserving and getting maximum use out of the mineral elements of soil is by the rotation of crops. In this way the same elements are not constantly being withdrawn from the soil. Tobacco, corn, and cotton use up large amounts of the mineral elements. By rotating these crops with alfalfa or clover, farmers can give the land a chance to recover. In addition, by growing alfalfa and clover, farmers add nitrogen to the soil. Certain bacteria, called nitrogen-fixing bacteria, live in nodules on the roots of plants such as peas, beans, alfalfa, clover, peanuts, and soybeans. These plants are known as legumes.



At the right is an enlarged photograph of the nodules on the roots of a red-clover plant.

Plants get their nitrogen from the soil, but there is nitrogen in the air which can be made available to plants. The nitrogen-fixing bacteria convert nitrogen from the air in soil into a form of nitrogen which plants can use. Thus alfalfa and clover enrich the soil by

adding nitrogen to it. You might like to refer again at this time to the third of the further activities on page 100 of this Manual.

Farming can be done on a very scientific basis. Soil can be analyzed. It is easy to determine what mineral elements any particular soil is lacking. These can then be added.

Crops grown on poor soil can endanger the health of all who eat them. For example, celery or other plants grown in poor soil will probably be deficient in phosphorous. This element is important in our diet. If we eat plants lacking in this vital element, our diet may be lacking in it, too. Thus our health can be endangered by improper farming practices.

On pages 168, 169, and 170 of *Experimenting in Science* the contour trenches and check dams described show methods and practices which can be used effectively to restore or reclaim abused land. The point is, however, that we should never allow our good productive land to get into such a condition.

Our economy depends to a major extent on wood and forest products. However, from a conservation point of view the forests of the earth are pre-eminently important because they help to control our water supply as well as enrich our soil.

The story of tree seeds is a fascinating one. "Great oaks from little acorns grow" has become a cliché, but the thought is one you may wish to emphasize to your children. Tree seeds are needed for conservation and reforestation as well as for many commercial purposes. About 75 million acres of land in this country require reforestation. It will take more than 100,000 tons of forest seeds for this tremendous task.

Tree seeds are usually gathered by hand. Tall forest trees must be climbed and the fruit or seeds collected by picking, cutting, or breaking them off. Seeds may also be collected from trees which have been cut down, but only if the trees have been felled after the fruit had started to ripen. Once the seeds have been collected they must be cleaned or separated from the fruit or cone that surrounds them. Then they are stored until used. Tree seeds are grouped in three different categories:

1. Seeds easily extracted from dry fruits. These include seeds in cones or pods.
2. Seeds which for all practical purposes are inseparable from the

dry fruits which surround them. Included are oak, chestnut, and trees such as elm and maple.

3. Seeds of fleshy fruits such as cherry, dogwood, apple, and pear.

The chart below gives some information about the gathering and storing of a few representative kinds of tree seeds. Photographs of these seeds and their fruit are shown on the opposite page. You may also wish to refer again to the material on seeds in the third chapters of *Experimenting in Science* and of this Manual. The concept of energy and plant growth may be re-emphasized at this time.

It is possible to grow trees in many areas of land which are not well suited to other kinds of crops. On almost every farm there is land which is not well suited for farm crops or pasture. Such land is not productive, and erosion takes place when there is a great deal of water runoff. There is much land of this type in the United States. A great deal of this land can support tree growth. If all this land were covered with a rich growth of trees, it would become productive. What was once barren soil could become useful and aid in the control of our water supply.

CHART 4 · SOME TREE SEEDS*

Tree	Type of seed	When seed should be gathered	Method of separating seeds from fruit	Amount of cleaned seeds per 100 lbs. of fruit	Best type of storage
Ash	Easily removed from dry fruit	Summer and fall	Seeds not separated	61–80 lbs.	Dry, cold
Beech	Easily removed from dry fruit	Fall	Threshing	21–40 lbs.	Moist, cold
Douglas fir	Easily removed from dry fruit	Summer and fall	Air or kiln drying	1–5 lbs.	Dry, cold
Oak	Tightly enclosed in dry fruit	Fall and winter	Seeds not separated	61–100 lbs.	Moist, cold
Pine	Easily removed from dry fruit	Throughout the year	Air or kiln drying	1–5 lbs.	Dry, cold
Plum	In fleshy fruit	Summer and fall	Depulping	11–20 lbs.	Dry, cold

*This chart is presented as background material for you. It is not intended that the material in it be taught to your children. The chart may be useful as you help children find answers to questions that arise concerning trees and seeds.

Pine fruit

Pine seed

Plum fruit

Plum seed

Ash fruit

Ash seed

Oak fruit

Oak seed

Beech fruit

Beech seed

Douglas-fir fruit

Douglas-fir seed

Photographs by Lynwood M. Chace

Ways of Working with Children

The goal you will want to strive for is to help the children see the importance of the wise use of our national and natural resources. In so far as possible, there has been an attempt in the chapter to translate principles into action which can be undertaken by the children. For example, on page 169 of *Experimenting in Science* the suggestion is made to think about your own community. The same erosion and runoff problems which beset us on a grand scale can be observed on a smaller scale in each and every community.

The children can take action in their own community to help prevent erosion or to reclaim such scarred areas as exist. Have the children make a preliminary survey of the community immediately around the school or in a nearby park. During the survey questions such as the following should be kept in mind:

Are there hillsides covered with so few plants that rain rushes down the slopes?

Do we have areas in which soil is being washed or blown away?

Are there areas in which trees or grass have been destroyed by fire or other causes?

Do we have areas in which small gullies are forming?

Through an initial discussion children may raise many more questions concerning problems which exist in the community and on which they can work, once the areas that need correction are found. With proper guidance and direction they can plan to do something about the problems if permission has been granted by the owner of the land. They might plan to build check dams in some small gullies, plant grasses or other cover material. They may even undertake to terrace a small hillside. In this way the accent will be on action—their own action—in which they can apply good conservation principles.

The children may have home gardens or school gardens in which vegetables and other crops are grown on a small scale. They may be encouraged to apply some good farming practices, such as planting crops along the contour of the land. A record of a school garden may be kept from year to year or from class to class and a crop-rotation system could be worked out. The concept of strip-cropping could also be worked out in such a school garden.

Arrangements may be made with the county agricultural agent to come to your class and discuss some of the problems and solutions to the problems which are being worked on in the larger community. The children should be prepared for his coming. They should discuss some of the problems with which they are concerned and with which the county agent may be able to help them.

Another project which may be undertaken is the reforestation of a tract of land which is near the school. Arrangements may often be made to plant trees on a small area of such land. It need not be an extensive project and it might be undertaken right on the school grounds. The trees and directions for planting them will probably be supplied by the Conservation Department of your state or province. Once such an area is started, it can provide many more opportunities for learning and pupil action.

On page 171 of *Experimenting in Science* another type of community survey is suggested: find out what some of the biggest uses of water are in your community. This probably can be accomplished most directly by having a committee visit or write to the Water Department. You can also get an estimate of how much water is used each day in your community. If a system of private wells is used, the information would probably have to be gathered by a direct survey by the children. The children could also conduct a survey in the class to find out how much water is used in each household for a period of a day.

Materials Needed

pail
seeds, grass
soil
water
watering pot
wire and wood, to build a check dam

Things You Can Do

See suggestions for children, page 187, *Experimenting in Science.*

1. You can build check dams, plant a grass covering, terrace the area, or use any other effective procedure suited to the area.

2. Fires are usually caused by carelessness with campfires or matches. A very small percentage of forest fires, probably less than 10%, are started by natural causes such as lightning. Debris left

on the ground in a forest area is a contributing cause to fires and should be cleaned up.

3. Contour-plowing and strip-cropping; the advantages of each can be found on pages 178 and 179 of *Experimenting in Science.*

4. The letter should state specifically what information is desired. The pupils can arrive at this as a group through discussion.

5. One can almost always find small areas in which insidious erosion is taking place.

6. The children might experiment with different materials and ways of building check dams.

Further Activities

1. A group might make a study of commercial fertilizers. Chile is a great producer of nitrates. Try to find out if there are any sewage-disposal plants supplying fertilizers to farmers or gardeners in your community.

2. What uses do we have for trees? A group might like to make a survey of various uses through the years of trees such as pine, spruce, birch, maple, oak, etc. For example, musical instruments are often made from red spruce; maple syrup comes from the sap of the maple tree; yellow dye was made by early pioneers from the bark of the black walnut. *The First Book of Trees* by Maribelle B. Cormack and other books on trees listed in the bibliography on page 117 of this Manual will be helpful. Children can also be encouraged to inquire into the sources of some of the products of trees which they see around them. Furniture, construction, and paper companies can be contacted to determine the kinds of trees from which their products are derived. Throughout the discussion, wise use and proper conservation methods could be stressed as well.

3. A group might make a study of various methods of land irrigation. Flooding is one type of irrigation. It is used particularly with grass crops. Furrow irrigation, border irrigation and sprinkling are types of irrigation which you may want to study. A mural showing each method of irrigation would be a good way to present the information to the rest of the class.

4. Men have built dams for a variety of reasons. For example, dams have been built to store water so that there will be an abundant supply of water when it is needed for irrigation during the grow-

Sprinkling

Border

Furrow

Flooding

These four types of irrigation are helpful in providing water for various kinds of crops.

ing season of plants. Make a study of the various large dams which have been built throughout North America. Where are they located? What areas do they serve?

5. Several children might make a study of various ways in which logs are cut into lumber. Visit a lumberyard. The people there will be able to supply much information to you. Letters might be written to the American Forestry Association, 919 Seventeenth Street N.W., Washington, D. C. This organization will be happy to supply your class with much useful information on forests and lumbering.

Evaluation

Evidence of changed behavior and a greater concern for the physical environment will give you an indication of the degree to which this study has been effective and worth while. Are your children more aware of spots in the community that need attention to protect the soil? Do they recognize conditions and practices in the community which are detrimental to the wise and proper use of soil, water, and wooded areas? Do they show evidence that they are willing to assume responsibility for the correction of such conditions?

The over-all understanding of the basic principles of wise use can best be assessed during the children's free discussions. Reports of some aspect of conservation from newspapers, magazines, radio, or television often form the basis for stimulating discussions. During the discussions do the children look ahead and try to see the implications? Do they attempt to analyze the situation on the basis of principles and facts? Do they confine their discussion to what is best rather than who is right? To what extent do they seek more information? How do they go about finding this information?

Bibliography

For the Teacher

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It,* Chapter 13. The Dryden Press, 1951.

Craig, Gerald S. *Science for the Elementary-School Teacher,* New Edition, Chapter 9 (pages 286–310) and Chapter 14 (pages 500–506). Ginn and Company, 1958.

Osborn, Fairfield. *Our Plundered Planet.* Little, Brown and Company, 1948.

Zim, Herbert S., and Martin, Alexander C. *Trees.* Simon and Schuster, Inc., 1952.

For the Children

Bell, Thelma Harrington. *Snow.* The Viking Press, 1954.

Bronson, Wilfred Swancourt. *Freedom and Plenty: Ours to Save.* Harcourt, Brace and Company, 1953.

Bruere, Martha Bensley. *Your Forests.* J. B. Lippincott Company, 1945.

Colby, Carroll Burleigh. *Smoke Eaters.* Coward-McCann, Inc., 1954.

Cormack, Maribelle B. *The First Book of Trees.* Franklin Watts, Inc., 1951.

Fenton, Carroll Lane and Mildred A. *Riches from the Earth.* The John Day Company, 1953.

Gaer, Joseph. *Everybody's Weather.* J. B. Lippincott Company, 1944.

Hogner, Dorothy. *Earthworms.* Thomas Y. Crowell Company, 1953.

Moore, Alma. *Friendly Forests.* The Viking Press, 1954.

Norling, Josephine S. and Ernest Ralph. *First Book of Water.* Franklin Watts, Inc., 1952.

Podendorf, Illa. *True Book of Trees.* Childrens Press, 1954.

Riedman, Sarah R. *Grass: Our Greatest Crop.* Thomas Nelson & Sons, 1952.

Riedman, Sarah R. *Water for People.* Abelard-Schuman, Inc., 1952.

Rounds, Glen. *Lone Muskrat.* Holiday House, 1953.

Schneider, Herman and Nina. *Rocks, Rivers and the Changing Earth.* William R. Scott, Inc., 1952.

Smith, Frances C. *First Book of Conservation.* Franklin Watts, Inc., 1954.

Wall, Gertrude Wallace. *Gifts from the Forests.* Charles Scribner's Sons, 1952.

Walsh, Mary Regina. *Water, Water, Everywhere!* Abingdon Press, 1953.

Webber, Irma Eleanor. *Thanks to Trees.* William R. Scott, Inc., 1952.

Films

ARTERIES OF LIFE. (EBF) 1 reel, color. Shows the role of forests in storing and regulating the flow of life-giving water to topsoil over large areas.

BIRTH OF THE SOIL. (EBF) 1 reel, color. Tells the fascinating story of how nature produces our precious life-giving topsoil.

FACE OF THE EARTH. (EBF) 1 reel, color. Describes the wearing-down forces on the earth, especially the action of running water.

FOREST CONSERVATION. (EBF) 1 reel, color. Tells of the ways in which man has destroyed forest resources and suggests what must be done to save these valuable resources.

FOREST GROWS. (EBF) 1 reel, color. Describes how forests grow and the factors which make a mature forest. Discusses temperature and rainfall in relation to the growth of trees.

FORESTS AND CONSERVATION. (Cor) 1 reel, b/w & color. Describes the critical problem of how to conserve and utilize our forest resources. Shows the contributions made by a progressive lumber company and the government.

GRASSLAND. (UW-Govt) 1 reel, b/w. Deals with the problem of soil conservation on the grazing lands of the arid southwestern United States. Shows how to curtail overgrazing of land.

EROSION. (UW-Govt) 1 reel, b/w. Discusses man-made and natural erosion including the destructive effects of wind and water. Emphasizes that destructive erosion can be prevented if conservation farming methods are used.

IMPORTANCE OF WATER. (BF) 1 reel, color. A graphic portrayal of the effort which many communities must make in order to secure and conserve an adequate water supply.

THE MEANING OF CONSERVATION. (Cor) 1 reel, b/w & color. Pictures what is being done to maintain our country's resources and natural beauty.

NATURE'S PLAN. (EBF) 1 reel, color. Describes the natural water cycle and how this provides water for all living things.

SCIENCE AND WOOD UTILIZATION. (Cor) ½ reel, b/w & color. Shows the part science plays in the conservation of trees by discovering ways of utilizing all the products of wood including waste products.

SEEDS OF DESTRUCTION. (EBF) 1 reel, color. Shows how man by unscientific practices has hastened the destruction of our forest resources. Suggests methods of forest conservation to be employed.

UNDERSTANDING OUR EARTH: SOIL. (Cor) 1 reel, b/w & color. Explains the soil profile (topsoil, subsoil, mantle rock, and bedrock) and presents a visual breakdown of the elements of soil.

WHAT IS SOIL? (IF) 1 reel, b/w. Through observation the composition and formation of soil is noted.

YOUR FRIEND THE FOREST. (EBF) ½ reel, color. Shows the value of forests and the necessity for preventing forest fires.

Filmstrips

CONSERVING WATER AND SOIL. (PDP) b/w.

FOREST RESOURCES. (Curr F) color.

GROW TREES FOR TOMORROW. (PDP) b/w.

HOW MAN DESTROYS SOIL. (SVE) b/w.

HOW NATURE DEFENDS SOIL. (SVE) b/w.

MINERAL RESOURCES. (Curr F) color.

THE SOIL. (JH) b/w.

SOIL AND ITS USES. (EGF) color.

SOIL RESOURCES. (Curr F) b/w.

WATER AND ITS IMPORTANCE. (EGF) color.

WATER CONSERVATION. (VS) b/w.

WATER RESOURCES. (Curr F) b/w.

WHAT IS SOIL? (EBF) b/w.

WHAT IS SOIL? (PSP) b/w.

WHY TREES ARE IMPORTANT. (PDP) b/w.

IX

Our Earth—A Huge Magnet?

The focus in this chapter is on the earth's magnetism. For centuries men have used the magnetic compass as a guide in their travels over the earth's surface. The compass and the principle of the compass are used in this chapter to stimulate and guide learning and experimentation. Each principle of magnetism that is developed through demonstration and experimentation is used to help clarify the concept of the earth's magnetism. Magnetism is a popular topic with children. It is an area which is well adapted for child experimentation.

Science Meanings for Children

Magnetism is a subject which is particularly appropriate to all levels of the elementary school. It is an area in which children usually have had experiences beginning as early as the kindergarten and many times in the pre-school years.[1] The very nature of the subject permits learning and activities which are appropriate to all levels of development. The following concepts are those which have been found particularly appropriate for eleven- and twelve-year-olds:

- A compass is a device which allows man to use the earth's magnetism.
- The idea and invention of a compass is only about 800 years old. Man made many discoveries about magnetism before he was able to build a compass.
- A certain type of rock called magnetite attracts iron. Magnetite is a natural magnet.
- If it is free to swing, one end of a magnet points in the direction we call north, and the other in the direction we call south.
- The needle of a compass is really a small bar magnet, mounted so that it can swing freely around.
- Both poles of a compass needle are affected by a piece of iron.

[1]Navarra, John G. *The Development of Scientific Concepts in a Young Child: A Case Study* (Bureau of Publications, Columbia University, 1955).

The north pole of a compass needle is attracted by the south pole of a magnet, but it is repelled by a magnet's north pole.

The south pole of a compass needle is attracted by the north pole of a magnet, but it is repelled by a magnet's south pole.

The earth itself seems to be a huge magnet. The north and south poles of compass needles are attracted by the magnetic poles of the earth.

A current of electrical energy can produce the same effect as a magnet.

The earth's magnetism is probably due to the rotation of the earth on its axis.

The earth has a magnetic field in which we all live.

The magnetic poles of the earth attract a compass needle, even though they are thousands of miles distant.

The sun affects the earth's magnetism.

Information for the Teacher

Discussion of the compass forms an important part of this chapter. Examine a compass. The needle of the compass is a piece of metal, usually iron, which has been magnetized and mounted on a pivot so that it can swing freely from side to side. One end of the compass needle points toward the north magnetic pole of the earth. The other end points toward the south magnetic pole.

The poles of a magnet are the areas in which its magnetic properties are most concentrated. The earth may be compared to a huge magnet in that the earth has been found to have magnetic poles which attract the magnetic poles of compass needles. The magnetic poles of the earth are quite different from its geographic poles. The geographic poles are the ends of the axis on which the earth turns. They are many miles distant from its magnetic poles. Refer to the maps on page 196 of *Experimenting in Science* to see the location of each of these poles.

On pages 190–192 of *Experimenting in Science* directions are given for making a compass. A bar magnet is used as the compass needle. This dramatizes the fact that the needle of a compass is really a bar magnet mounted so that it can swing freely around. The end of the needle which points toward the north is called the north pole of the compass needle.

Children are often confused when they learn that opposite poles attract, and then notice that the end of the bar magnet marked "N" points to the north magnetic pole. The reason for this is historical rather than scientific. When men first learned that one end of a freely swinging magnet always points north, they knew nothing of the laws of magnetism. They named the north-pointing end the north pole of the magnet. We now know that opposite poles attract, but the historical error still persists.

On pages 193 and 194 of *Experimenting in Science* the laws of magnetic attraction are developed. Essentially, the laws of magnetic attraction are that like poles repel and unlike poles attract. This means that a north pole of a magnet will repel the north pole of another magnet, and a south pole will repel a south pole, since these are similar poles. But a north pole will attract a south pole, since these are opposite poles. In the illustrations on page 194 a bar magnet and a pocket compass are used. For a demonstration before a large group it might be well to use the compass made from a bar magnet and wooden stand which is described on pages 190 and 191.

On pages 197–203 of *Experimenting in Science* two different theories of magnetism are developed: the molecule theory of magnetism and the electron theory of magnetism. The electron theory is essentially a further development and refinement of the molecule theory. The molecule theory offers an explanation on the basis of molecules alone. The electron theory deals with the atom and the electrons which make up the atom.

In simple terms, the scientists who developed the molecule theory of magnetism said that each iron atom was a very tiny bar magnet. In this theory each of the tiny molecule magnets would have a north and south pole, just like a large bar magnet. When the iron is magnetized, the tiny molecule magnets would be arranged in order with all the north poles facing in one direction and the south poles facing in the opposite direction. Illustrations of this can be seen on pages 198 and 199 of *Experimenting in Science.*

On page 200 of the text the development of the electron theory is described. This theory was developed because of the discovery of new facts about magnetism and the inadequacy of the old theory to explain these new discoveries satisfactorily. These discoveries have to do with the fact that a current of electricity can produce the same effect as a magnet. Directions for a simple demonstration are found

on pages 200 and 201 of *Experimenting in Science*. By means of the demonstration it is shown that a compass needle moves when an electric current flows above it.

The electron theory is based on two premises: (1) a current of electricity is produced by moving electrons; (2) a current of electricity can produce a magnetic effect. You may want at this time to refer again to the material on atoms and electrons on pages 13–17 and 83–84 of this Manual. You will recall that each atom of each element has one or more moving particles called electrons. Each electron rotates, or spins on its axis, while it revolves around the

This is one way of experimenting with the relationship between electricity and magnetism. When the circuit is completed, the nail becomes an electromagnet.

Wahl-Coats Elementary School, Greenville, North Carolina. J. D. Henry

center of the atom. Atoms of various elements differ from each other in their number of electrons. Atoms of the element iron each have twenty-six electrons spinning around the nucleus. The motion of these many electrons in iron atoms is believed to produce a kind of electric current when most of the electrons spin, or rotate, in the same direction. According to the electron theory, magnetism is caused by this motion, or current, of many electrons spinning in the same direction.

There is no one complete explanation of the earth's magnetism. There are numerous theories. On page 204 of *Experimenting in Science* two theories are presented. The first theory is based on the fact that the earth has in it much material which may be magnet-

ized. The hypothesis is that the core of the earth is composed of nickel and iron. Each of these substances can become magnetized. The proponents of this theory consider that the earth's rotation has brought about the magnetism of the nickel-iron core, which in turn is responsible for the earth's magnetism. The second theory is based on the production of electric currents in the earth. On pages 208–209 of *Experimenting in Science* the effect of the sun on the earth's magnetism is described. There are theories which state that the earth's magnetism is due to the sun rather than the earth. More than likely, there are multiple causes for the earth's magnetism.

The concept of the earth's magnetic field is developed on pages 205–208. When an object is attracted by a magnet, it is within the field of the magnet. The demonstration with the pin and nail on page 206 of the text develops the understanding of the invisible field of a magnet reaching out through space to attract objects. The demonstration with the iron filings described on pages 206 and 207 of the text gives a graphic representation of the field which surrounds a magnet. These demonstrations should help your children develop a concept of the earth's magnetic field which surrounds us. We can see the effect of the earth's magnetic field through the movement of the compass needle.

Ways of Working with Children

Throughout the study of magnetism a feeling should emerge: here is a force, here are concepts, about which all is not known. There will probably be many new discoveries, many refinements and revisions of these concepts during the lives of your children. And yet children can learn about this force and these phenomena. They can discuss magnetism, they can experiment with it, and they can begin to evaluate the various theories and explanations. Above all we should want the children to feel that science is not something alien. It is something close to them and with which they already have a certain familiarity. It was out of such a feeling that the chapter *Our Earth—A Huge Magnet?* was constructed.

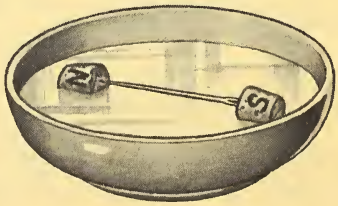
The authors believe that this feeling indicates an important way of working with the children. There should be ample time to discuss the pros and cons of different questions which arise. As you will note, in most cases more than one explanation or theory has been

indicated. Children could be encouraged to evaluate and discuss each of these with reference to the earth's magnetism. They would, of course, need to do additional research and reading. This could lead to individual reports as well as many valuable group discussions during which ideas would be propounded and clarified. It would also give the teacher an important indication of the way individual children are progressing in the handling of ideas and information.

The molecule theory of magnetism and the electron theory of magnetism can be used to illustrate the historical growth of scientific ideas. A group of children may be interested in developing this into a special project. They may wish to trace the way in which some ideas and theories have changed. One of these reports could deal with the creation of new man-made elements. This would tie in with the concept of the atom which is developed in the theories of magnetism in the text. Such a report would probably touch on the work of the early alchemists as well as the current work going on with the atom and atomic energy. Much new material on this subject is being written for children. We can expect a great deal more in the future.

Throughout this chapter there are many experiments and demonstrations. There are some which you may want to do with the group as a whole. Others may first be undertaken by small groups and then performed by them for the whole class. For example, the compass described on pages 190 and 191 of the text may first be constructed by a small group and they in turn may demonstrate it to the larger group.

Encourage the children to develop variations of the experiments. For example, the principle of the compass may also be shown by magnetizing a darning needle, thrusting each end into a small cork, and floating this in a bowl of water. The cork which points toward



the north could be marked with an "N"; the cork which points toward the south could be marked with an "S." As you can see, this is a crude type of compass. On page 199 of *Experimenting in Science* you will find directions for stroking a nail to make it a magnet. You can apply these same directions to magnetize the darning needle.

Materials Needed

cardboard
common pins
compass
corks
crayon
doorbell
dry cell, No. 6
globe
hammer
iron filings
magnets, bar and horseshoe, including one small horseshoe magnet (ten-cent variety)
nails, iron
needles, 2 darning and 1 steel knitting
paper, circular piece
paper clips
stand, wooden
string
tumbler
wire, insulated copper

Learning More about the Earth's Magnetism

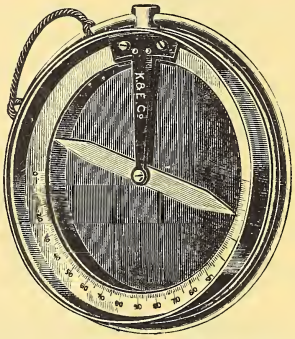
See suggestions for children, page 210, *Experimenting in Science.*

1. Use a 60-penny nail if you can get it. The north pole of the compass needle should be attracted to both ends of the nail before it is struck. The earth's magnetic field will induce the nail to become a magnet when it is struck. Make sure that the nail is held in a north-south position. Otherwise the experiment may not be successful.

2. You might contact the Air National Guard in your vicinity. They will be more than happy to supply a person to talk to your group.

3. You are actually making a dipping needle. This is a device which is used to determine the direction of the lines of magnetic force at any point on the earth's surface. It differs from a compass in that it consists of a magnet mounted on a pivot in such a way

that it can swing freely up and down rather than from side to side. The illustrations on page 207 of *Experimenting in Science* show the magnetic fields of two magnets and of the earth. You will note that the lines of magnetic force slant toward the magnets and the earth at varying degrees, depending upon their proximity to the poles. The degree with which the lines of magnetic force dip toward the earth in any region is indicated by the degree with which a dipping needle tilts downward. To be used properly, a dipping needle must always be placed so that it is pointing in a north-south direction with its north pole pointing toward the north.

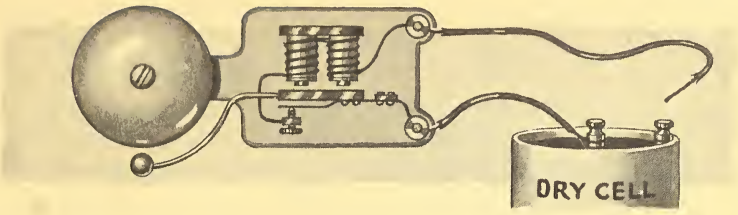


Courtesy Keuffel & Esser Company

The dipping needle provides us with an accurate estimate of the direction of the earth's lines of magnetic force in any particular area.

Further Activities

1. A compass does not always point true north. This is due to the fact that the geographic north pole is some distance from the magnetic north pole. The difference in compass direction between true north and magnetic north is known as magnetic declination. The compass may point east of true north or west of true north, depending upon where it is located. Study a map of North America or study a globe. Locate the magnetic north pole. Locate the geographic north pole. Locate your town on the globe. Your compass would point toward the magnetic north pole. Does your compass point east or west of true north? Invite a navigator of a ship or airplane to your class. He will have charts on the magnetic declination of places all over the earth. Ask him to explain how he uses these charts to help him navigate. Maybe one of the parents in your school was a navigator or studied navigation while he was in the army or navy. He probably would be very happy to come and help you with your questions.



2. Have the children examine a doorbell. They may have to remove the cover. Do they see the two round parts that look like spools of wire? The wire is wrapped around soft iron which becomes an electromagnet when a circuit is formed. Connect the doorbell to a dry cell. The electromagnet attracts the iron hammer when electricity flows through the wire. A group might list some other ways in which electromagnets are used. This list would include such things as the telegraph, telephone. Encourage the children to look up further information on these topics and report to the class.

3. Wrap an insulated wire several times around a nail. Connect one end of the wire to a dry cell. Now hold the other end of the wire to the second post of the dry cell, as in the illustration on page 122 of this Manual. Electricity flows through the wire and the nail becomes a magnet. This set-up is called an electromagnet. When you disconnect the wire, the nail is no longer a magnet.

4. When a watch is worn near magnets or electrical machines, it will become magnetized if it is not protected properly. A watch repairman might be invited to your class to talk to you about how this occurs and how a watch is repaired when this happens.

Evaluation

You might have the children as a group summarize some of the important learnings from this study. Have the children express themselves in as spontaneous a way as possible. Sometimes in such informal groupings and discussions children will participate who otherwise would not have done so.

The meanings that the children select need not necessarily be confined to those listed for this chapter on pages 119–120 of this Manual. The list compiled by the children might be contrasted with the list in the Manual. The comparison would probably supply you with leads for directing further discussions.

The children in your class might plan to hold a panel discussion on some of the important ideas in the chapter. Invite another class to come in. At the end of the discussion the visitors could be encouraged to ask questions. These questions will help clarify ideas for your group as well as the visitors. The type of presentation the panel makes as well as the way they handle the questions from the group should be noted carefully. How did they document and support their statements? Did they give a dogmatic presentation or did they allow for the element of uncertainty that is involved in this topic? How did the panel handle the questions? Were they willing to say, in some instances, "I don't know"? Did they at times say something such as, "There are a number of explanations for that"?

How does the group react as they listen to a panel discussion? Are they willing to accept tentative conclusions? Do they question certain statements? Do they ask whether certain conclusions are in agreement with statements of authorities? Do they accept new ideas when they seem reliable? How do they react when they hear that two authorities are in disagreement? Are they willing to accept the idea that man has much to learn and as a result has not come to a final, acceptable explanation of many things?

Bibliography

For the Teacher

Beeler, Nelson F., and Branley, Franklyn M. *Experiments with Atomics.* Thomas Y. Crowell Company, 1954.

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It,* Chapter 21. The Dryden Press, 1951.

Burnett, R. Will. *Teaching Science in the Elementary School,* Chapter 9. Rinehart & Company, Inc., 1953.

Craig, Gerald S. *Science for the Elementary-School Teacher,* New Edition, Chapter 23. Ginn and Company, 1958.

Hecht, Selig. *Explaining the Atom, Revised Edition.* The Viking Press, 1954.

Parker, Bertha M. *Science Experiences.* Row, Peterson and Co., 1952.

Rowland, John. *Atoms Work Like This.* Roy Publishers, 1956.

Yates, Raymond F. *Fun with Electrons.* Appleton-Century-Crofts, Inc., 1945.

For the Children

Bendick, Jeanne. *Electronics for Young People.* McGraw-Hill Book Company, Inc., 1955.

Bischof, George P. *Atoms at Work.* Harcourt, Brace and Company, 1951.

Epstein, Samuel and Beryl W. *First Book of Electricity.* Franklin Watts, Inc., 1953.

Hyde, Margaret O. *Atoms Today and Tomorrow.* McGraw-Hill Book Company, Inc., 1955.

Meyer, Jerome Sydney. *Picture Book of Electricity.* Lothrop, Lee & Shepard Company, Inc., 1953.

Meyer, Jerome Sydney. *Picture Book of Molecules and Atoms.* Lothrop, Lee & Shepard Company, Inc., 1947.

Parker, Bertha M. *Magnets.* Row, Peterson and Co., 1949.

Potter, Robert Ducharme. *Young People's Book of Atomic Energy.* Dodd, Mead & Company, Inc., 1952.

Shippen, Katherine B. *The Bright Design.* The Viking Press, 1949.

Sootin, Harry. *The Marvelous Magnet.* Julian Messner, Inc., 1953.

Wyler, Rose. *The Planet Earth.* Abelard-Schuman, Inc., 1952.

Zim, Herbert S. *What's inside the Earth?* William Morrow and Company, Inc., 1953.

Films

MAGNETISM. (Cor) 1 reel, b/w & color. Illustrates what magnetism is, how it works, and how it differs from electricity. Shows types of permanent magnets, electromagnets, and bar magnets. Discusses attraction and repulsion and magnetic fields.

MAGNETS. (YAF) 1 reel, b/w. Pictures a few of the simple and basic facts about bar magnets.

STORY OF ELECTRICITY. (KB) 1 reel, b/w. Describes some of the historical events which led to man's use of magnetism. Includes the early discovery of lodestone and the characteristics of magnetism. Discusses the contributions of Morse, Edison, and others in the development of the use of electricity.

THE SUN. (ISO) 1 reel, b/w. Studies the sun and sunspot groups. Shows a total eclipse of the sun and hydrogen explosions on the rim of the sun.

TAGGING THE ATOM. (HFC) 1 reel, b/w. Deals with radioisotopes and "hot tracers."

Filmstrips

ELECTRIC MAGNETS. (SVE) b/w.

ELECTRICITY. (EBF) color.

MAGNETS. (EBF) color.

MAGNETS. (YAF) b/w.

PERMANENT MAGNETS. (SVE) b/w.

THE WONDER OF ELECTRICITY. (EGF) color.

X

Machines to Direct Energy

Energy and energy sources have always been a concern of our culture. Man's success has been based to a large extent on his ability to put energy to use. Machines are the predominant factor in this successful use of energy. Almost everywhere we turn we can see ourselves surrounded by machines.
In this chapter children are helped to understand the historical development of machines, their impact on man, and their basic principles. The primary focus is on the six basic machines.

Science Meanings for Children

All children have observed machines and to an extent have used machines in their play, work, and the general activity of living. Each child will bring a variety of experiences to this subject. The following meanings indicate some of the directions and concepts toward which you may guide them:

Man uses machines to do work.

A machine is anything which connects a source of energy with work to be done. In this sense the human body is a machine.

We do not use less energy when we make use of machines, but they enable us to use energy more effectively.

The inclined plane helps us to lift heavy objects.

The lever helps man concentrate energy at one spot.

The sledge and the wheel are means of reducing friction.

Much of our daily living is affected by the invention of the wheel and axle.

The windlass is a form of wheel and axle.

The wedge has a double inclined plane.

The spiral, or thread, of a screw is similar to an inclined plane.

Pulleys make work seem easier by allowing the work to be spread out.

Man combines basic machines to make complex machines.

Information for the Teacher

Most of the materials which we use are the products of machines. Many simple devices, such as household articles, are themselves machines. There are really only six basic or simple machines. Other machines are made of the six basic machines. There are countlesss numbers of complex machines. Each serves a particular purpose or performs a particular job, but all are combinations of the six basic machines.

The six basic or simple machines are the inclined plane, the wedge, the screw, the lever, the wheel and axle, and the pulley.

The inclined plane is merely a sloping surface. A road winding around a mountainside and a ramp connecting two levels of different heights are examples of inclined planes.

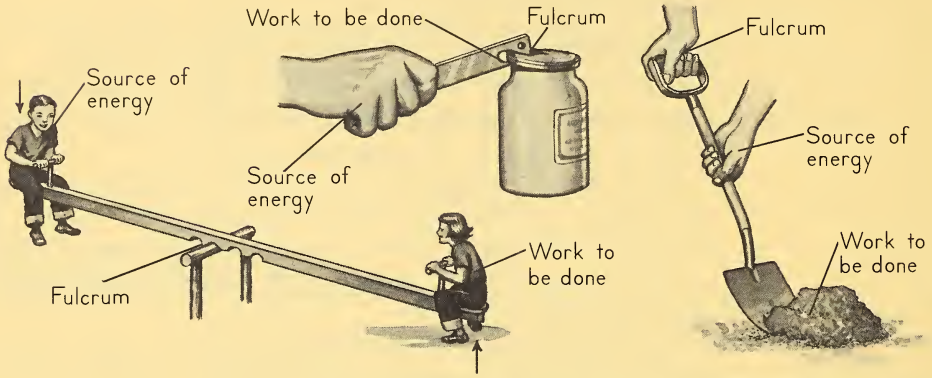
When a barrel is rolled up a ramp, a simple machine is being used. The ramp is an inclined plane. The ramp makes it easier to get the barrel up to the required height. It might be impossible for a man to lift the barrel directly from the ground. But by rolling it up the ramp, he is able to do the job.

The wedge consists of two inclined planes back to back. Knives and axes are wedges. Examine a knife and you will see that it slopes up from its cutting edge to its back to form two inclined planes. As a wedge is forced into an object, it pushes the object apart.

The screw also consists of an inclined plane. The thread of the screw is an inclined plane which travels around and around, along the length of the screw. Screws may be of several different types, among which are wood screws and machine screws. The wood screw is made of metal and it has a pointed end so it will pass into wood easily. Machine screws have blunt ends and they are used to hold together metal pieces. The hole into which the machine screw is placed must be prepared; that is, the hole must have a thread on the inside. Nuts may be used on machine screws. As you know, a nut is a piece of metal with a thread on the inside.

The lever is a bar used in such a way that it turns about a fixed point called the fulcrum. In the diagrams on the next page you can see three possible arrangements of the lever. The one most frequently used in demonstrations is the arrangement with the source of energy and work to be done on opposite sides of the fulcrum. In the second arrangement the work to be done is between the fulcrum

and the source of energy. We must pull up to move the weight up. In the third arrangement the source of energy is between the fulcrum and the work to be done. Look at the diagram of a shovel of sand being lifted. This is an example of a lever of the third type: the work to be done consists of the sand to be lifted; the lifting force is being applied by the hand near the middle of the shovel handle; the fulcrum or fixed point around which the shovel is moving is at the end of the shovel handle which is being grasped in the other hand.



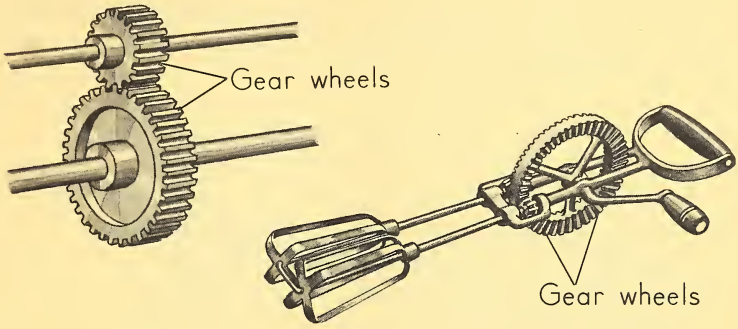
Levers are a part of many things used each day: scissors, nutcrackers, brooms, shovels, wheelbarrows, can openers, crowbars, and seesaws.

When a wheel is fastened to a rod in such a way that the turning of the wheel turns the rod, the combination is called a wheel and axle. Doorknobs and automobile steering wheels are examples of the wheel and axle.

Gear wheels are further developments of the wheel and axle. In the diagram on the opposite page you can see two gear wheels. Each gear wheel is really a wheel and axle. However, each wheel is equipped with teeth. The teeth of one wheel interlock with the teeth of the other wheel. This arrangement of wheels allows power to be transmitted from one shaft or axle to another shaft or axle.

A very common object used in most kitchens will help you understand the principle of the gear wheel. Look at an egg-beater and you will see an arrangement of gear wheels. There is a large gear wheel with a handle attached. This wheel interlocks with the smaller gear wheels at the bottom. When the handle is turned, the larger wheel

turns the smaller wheel. The beaters are attached to the shaft of the smaller wheels and spin along with them. The smaller wheels turn much faster than the larger wheels. The gear arrangement makes it possible to operate the egg-beater rapidly.



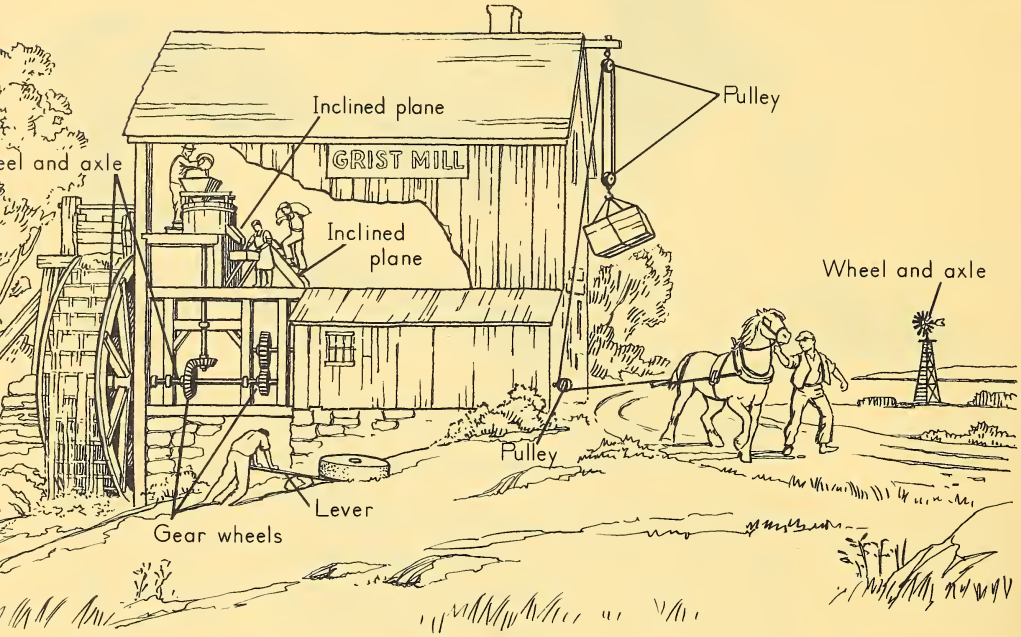
The pulley, in its simplest form, is a wheel over which a piece of rope is passed. The wheel may have a rim on each side of it to prevent the rope from slipping off. As the rope moves smoothly over the wheel, the wheel turns.

A single pulley fastened as in the illustrations on page 230 of *Experimenting in Science* is called a fixed or stationary pulley. With a single fixed pulley the advantage gained is one of direction. That is, it enables you to lift a flag by standing on the ground and hoisting the flag to the top of the pole. However, there are pulley arrangements called compound pulleys which help us gain force at a sacrifice of distance. The illustration on page 231 of *Experimenting in Science* shows the simplest of these arrangements. In this arrangement, when the weight is raised one foot, each of the ropes supporting it must be shortened by 1 foot. Since there are two supporting ropes, the free end of the rope held by the boy must be pulled through 2 feet. With this arrangement of pulleys it takes about half the force to lift the weight that it would require with a fixed pulley alone.

Ways of Working with Children

The opening spread of this chapter is filled with a variety of applications of the basic machines and combinations of these machines. Discussion may center around the work that is

being done and the source which supplies the energy. The machine in each case is the intermediary or link. The key, on this page, of the opening spread of this chapter on pages 212–213 of the text may be helpful to you. It may suggest some of the things which you will want to emphasize in this chapter. The theme of the chapter is directing energy by use of machines. In the illustration the energy of falling water is being directed by the use of the simple machine



called the wheel and axle. This is evident in the water wheel itself and in the attached gear wheels. Man's energy is being directed by the use of the lever and inclined plane as indicated in the key. An animal's energy is being directed by the use of pulleys. The energy of the wind is being directed by the use of a wheel and axle arrangement known as a windmill.

The discussion of the opening spread may lead to a preliminary type of exploration. The children may be encouraged to make a survey of the community to find what machines are being used.

They may visit building sites, gasoline stations, printers' shops, machine shops, lumberyards, various kitchens, and other places where work is being done. They could compile a list of the machines being used in the community. Beside the name of each machine would be additional information: the work which was being done and the source which supplied the energy to do the work. This activity would help to point up the concept of the machine as a link, or connection, between the source of the energy and the place where the energy is to be used.

Beginning on page 214 of the text there is a brief historical treatment of machines. This brief treatment may be extended by encouraging children to make reports on the development of machines in our own culture. Comparisons could be drawn between the 19th century and 20th century. What has been the influence of the machine on our living, our work as well as our play? Some child may be interested in studying how one particular product has been improved, that is, the automobile. There is a wealth of material on the subject. Our modern kitchens are a result of the application of machines to the work to be done. This would provide another topic which could be treated historically. How has the work in the kitchen changed during the last fifty or hundred years? What kind of machines do we find in the kitchen?

A good deal of the emphasis in this chapter is on experimentation. The experiments described in the chapter, *Machines to Direct Energy* are the type which the children can easily follow and duplicate. The principles will be much more meaningful if the experiments have actually been performed by the children. Some of the activity will be carried out best on a playground or other suitable outdoor area. This will involve planning and discussions, the allocating of responsibility, as well as co-operation among the members of the group.

The experiments in the text have also been selected so as to provide for variations. As the children experiment, they may be encouraged to vary the experiment. For example, on pages 216, 217, and 218 the length of the planks, the load of the wagon, as well as the size of the wagon are a few of the variations that may be introduced. If no wide planks are available, the children can easily construct 3- and 5-foot ramps, wide enough to accommodate a child's wagon. The loads can be weighed on any type of bathroom scales.

It is not necessary that the entire load be weighed at once. This experiment as well as the others in the chapter may be performed again and again.

The children may be encouraged to record the data. For example, using the 5-foot plank, load the wagon successively with 100 lbs., 80 lbs., 60 lbs., 40 lbs., 20 lbs. With how much force do you have to pull to move the wagon up the incline? They can repeat this with the 3-foot plank and make comparisons among the data.

On pages 220 and 221 of the text it is wise to encourage the children to experiment with the fulcrum in different positions. By using a large wooden box and a 2×4 as a lever, they can get an even better "feel" that the lever makes the work easier to do. The wooden box should be large enough for a child to sit in it. The 2×4 should rest on a fulcrum. By gentle pressure on one end of the lever one child can easily lift the box in which another child is seated. This should be carefully supervised and the box need not be lifted higher than an inch or two to get the "feel."

On page 221 the spot pictures of the various kinds of useful levers can provide a good point of discussion. The discussion of each may center around where the fulcrum is, where the force would be applied, and what work can be done. The children may be encouraged to bring various kinds of levers to school and make such an analysis for each one.

The flagpole outside the school is a very convenient place to show the use of a fixed pulley. Pulleys for the various experiments can, of course, be purchased in hardware stores or other shops in town. However, some very simple types may be made either in the woodworking shop or right in the classroom. Such activity is always useful and provocative. It will help toward a clear understanding of the pulley as well as stimulate unpredictable discussions.

Many windows are lifted by a simple pulley device. In some windows these pulleys are exposed and can be examined. Encourage the children to find and report other common uses of pulleys around the house, school, and community. Many clotheslines are operated by simple pulley arrangements.

Examination of toys with which the children play is always a good idea. For example, bicycles can illustrate many principles, such as the use of gear wheels and the use of belts or chains to drive the wheels. Many times the children will be more familiar than an adult

Quantitative relationships are important in experimenting with pulleys and other simple machines.

Wahl-Coats Elementary School, Greenville, North Carolina. J. D. Henry

with the operation of these machines. Many wholesome aspects of learning can accrue to the teacher as well as the group by letting a well-informed "Edison" take over for a while.

Materials Needed

bit and brace
bricks, 2 or 3
broomstick, 18 inches long
hammer
hook, for pulley
nails
paper
pencil
pulleys, 2
rocks or bricks, weighing about 100 pounds in all
scales, bathroom
screw
soil
spring balance
wagon, child's
wheels, 1 each of 2 different sizes, such as 6 inches and 1 foot in diameter
wood, assorted pieces including 1 board $\frac{3}{4}'' \times 3'' \times 3'$, 1 block $2'' \times 4'' \times 6''$, 2 pieces 24 inches long, and boards to make stands and wedges
yardstick

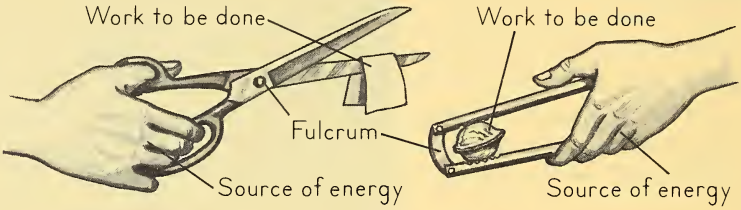
Learning More about Machines

See suggestions for children, page 233, *Experimenting in Science.*

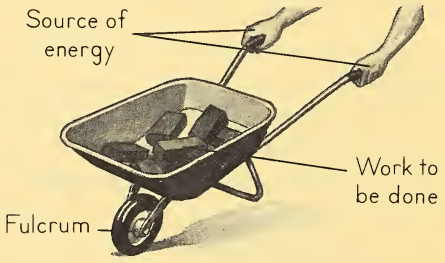
1. The shovel arm is a lever.

2. The answer depends on the machines selected.

3. In a pair of scissors the fulcrum is between the source of energy and the work to be done. In a nutcracker the work to be done is between the fulcrum and the source of energy. Notice the diagram of scissors and a nutcracker below.



4. See the diagram of a wheelbarrow below. The whole wheelbarrow is a lever. The fulcrum is at the wheel. The work to be done is between the fulcrum and the source of energy.



Further Activities

1. You might plan a visit to a garage or repair shop. Arrange to have the children examine a gasoline engine which has been taken apart or is in the process of repair. The mechanic will be able to answer many of the questions. If you have a committee of children meet with him to plan the visit, the trip can be very profitable.

2. You might make arrangements with a railroad to have the children shown a steam engine and also a diesel engine.

3. Plan to visit a building project when construction is in progress. What machines do you find being used? Encourage the children to analyze the work that is being done and to suggest ways the jobs could be made easier by employing simple or complex machines. If there are power shovels, bulldozers, and other pieces of heavy equipment present, inquire if someone is available to explain their operation. If a child in the class is related to a contractor or someone in the contracting business, it probably would be wise to make arrangements for visitation through such a person.

4. Examine the tools which are used in the school workshop. What principles of machines are involved in the various tools? For example, a wrench, hammer, shears, chisel, screwdriver can all be used so that they involve or employ the lever principle. An ax is a wedge on a handle. Are pulleys and other simple machines in use on some of the tools in the shop?

5. One or more of the children might make a study of lubricants. Large quantities of lubricating oils are used to control friction. Questions might be proposed, such as: What are some machines that you know have to be oiled? What parts of your bicycle must you lubricate? Why is motor oil used in an automobile? Wherever there are moving parts in machines, there is probably a need for lubricating oil to reduce friction.

6. Ask the children to examine the brakes on a bicycle. How do they make use of friction? If you visit a garage, ask the mechanic when he will be working on the brakes of an automobile. Visit him again when he is repairing a set of brakes. Ask him to explain how they work. He will also be able to tell you the difference between hydraulic brakes, mechanical brakes, and air brakes.

Evaluation

This chapter provides much opportunity for group activity and co-operation during experiments. Some very significant trends may be noted in the behavior of the groups and the individuals comprising the groups. The following questions may be kept in mind to aid in the evaluation of their behavior:

Did the group plan well before undertaking the experiments? How did they decide on the materials and amounts needed to perform the experiments?

Was the group able to carry through on its own initiative; did they plan and put the plans into action? Was the teacher's intercession continually necessary to keep the group on the right track?

How were the individual activities co-ordinated? Did a strong leader emerge or did the children arrive at decisions through discussion? Did they respect other points of view?

How did they gather their data? When discrepancies in their results occurred, what did they do? Did they repeat the experiment? Were they curious as to the cause of the discrepancy? Did they consider every possible side before they drew a conclusion?

How were the activities co-ordinated among the various groups?

In general the above questions deal with evaluating the behavior of the groups and individuals during the process of working with the materials and ideas of the chapter, *Machines to Direct Energy.* Out of this work with the materials and ideas should also come a greater awareness of machines and what they have meant to our culture. Do the children recognize that it has been through man's ingenuity that our complex machines have been created out of the six basic machines?

Bibliography

For the Teacher

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It,* Chapter 20. The Dryden Press, Inc., 1951.

Craig, Gerald S. *Science for the Elementary-School Teacher,* New Edition, Chapter 22. Ginn and Company, 1958.

For the Children

Barrow, George. *Your World in Motion: The Story of Energy.* Harcourt, Brace and Company, 1956.

Bechdolt, Jack. *Going Up: The Story of Vertical Transportation.* Abingdon Press, 1948.

Blough, Glenn O. *Doing Work.* Row, Peterson and Co., 1948.

Bothwell, Jean. *First Book of Roads.* Franklin Watts, Inc., 1955.

Burlingame, Roger. *Machines that Built America.* Harcourt, Brace and Company, 1953.

Elting, Mary. *Machines at Work.* Garden City Books, 1953.

Hertz, Louis Heilbroner. *Making Your Model Railroad.* Thomas Y. Crowell Company, 1954.

Huey, Edward G. *What Makes the Wheels Go Round.* Harcourt, Brace and Company, 1952.

Parker, Bertha M. *Machines.* Row, Peterson and Co., 1948.

Peet, Creighton. *How Things Work.* Henry Holt and Company, Inc., 1941.

Schneider, Herman and Nina. *More Power to You.* William R. Scott, Inc., 1955.

Schneider, Herman, and others. *Everyday Machines and How They Work.* McGraw-Hill Book Company, Inc., 1950.

Todd, Ruthven. *Trucks, Tractors and Trailers.* G. P. Putnam's Sons, 1954.

Zaffo, George J. *Big Book of Real Building and Wrecking Machines.* Grosset & Dunlap, Inc., 1951.

Zim, Herbert S. *What's Inside of Engines?* William Morrow and Company, Inc., 1953.

Films

How Machines and Tools Help Us. (Cor) 1 reel, color. Shows how man has devised ways of making work easier by means of simple tools and engines and motors.

Machines Do Work. (YAF) 1 reel, b/w. The concept of the simple machine is demonstrated by the lever, the inclined plane, the pulley, and the wheel and axle.

Simple Machines. (Cor) 4 films, ½ reel each, b/w & color: Inclined Planes; Levers; Pulleys; Wheels and Axles. Illustrations and demonstrations to apply the principles and understand the functions of simple machines.

Simple Machines. (EBF) 1 reel, b/w. Explains and demonstrates the six basic machines.

What Are Machines? (EBF) 1 reel, b/w. Defines what a machine is, how machines developed, and how machines have changed our way of living.

Filmstrips

Machines. (EBF) color.

Machines for Daily Use. (EGF) color.

Simple Machines. (SVE) b/w.

Simple Machines. (YAF) color.

XI

The Earth's Airways and Beyond

The concepts of the space above the ground—from the earth's surface to the moon and beyond—and man's travel through this space in balloons, dirigibles, airplanes, helicopters, "jets," and rockets form the basis of this chapter. The basic principles of flight through the air are developed through simple demonstrations and experiments. The concept of airways is introduced to give a feeling for air travel and time. Problems of space travel as they have been met and as they may be met are introduced with a promise of greater journeys into space in the future.

Science Meanings for Children

The fact of air transportation and the concept of air travel influence each of us each day. Children are curious about air travel, and if we take the time we find that they have a tremendous reservoir of information about air and space and travel. They are surrounded by many sources of information. Much of it is fictional. There are, of course, inaccuracies in much of the information that comes to children. The following meanings, which are developed in this book, are designed to provide a basic and reliable source of information about some of the most common and challenging concepts of air travel as we know it today and as it may be in the future.

Balloons and dirigibles rise because the gas which they contain weighs less than the surrounding air.

The airplane flown by the Wright brothers in 1903 was the first aircraft which did not depend on a lighter-than-air gas for its lift.

The wings of airplanes make flying, as we know it, possible.

Fast-moving air has less pressure than slow-moving air.

Propellers pull a plane forward through the air.

A jet plane is pushed forward as expanding hot gases escape from the rear of the jet engine.

Some jet planes travel faster than sound.

Four forces act on a plane in flight: thrust, lift, gravity, and drag.

From north to south, east to west, airways link our cities.

Helicopters have moving wings.

The higher we go, the less oxygen there is in the air.

Our bodies need a certain amount of oxygen to remain healthy and active.

At heights above 20,000 feet special oxygen-supplying equipment is needed.

Pilots who fly in aircraft above 10 miles wear special flying suits.

Gasoline engines and jet engines will stop operating at high altitudes because of a lack of oxygen to burn the fuel.

Rocket engines carry their own oxygen supply.

Fuels are being developed to give greater power to rockets.

Heat is a real problem in space travel.

Many problems arise with each new step in space travel.

Information for the Teacher

One of the most important concepts which run through this material is the shrinking size of the earth in terms of time required to move from one portion of the globe to the other. This is the theme of the opening spread and the material on pages 234 and 235 of *Experimenting in Science.* This theme is also developed on pages 246 and 247. Each airway on the map of North America on page 246 is marked with a certain number of hours. The global map on page 247 is marked in miles. It is important to remember that the flying times indicated are subject to changes almost from day to day. A good source of current information concerning flying times would be the major airlines. Stories are often carried in newspapers on the flying time between various points.

The earliest type of air travel which man was able to undertake was done in balloons. In the late eighteenth century two Frenchmen built a balloon which was capable of carrying two men. The lifting force for the balloon came from the fact that it was filled with air which had been heated by burning wood. The hot air in the balloon was lighter than the surrounding cooler air, and thus the balloon rose. Such a balloon would rise and then lose altitude as the hot air began to cool.

Present-day balloons and dirigibles are based on the same prin-

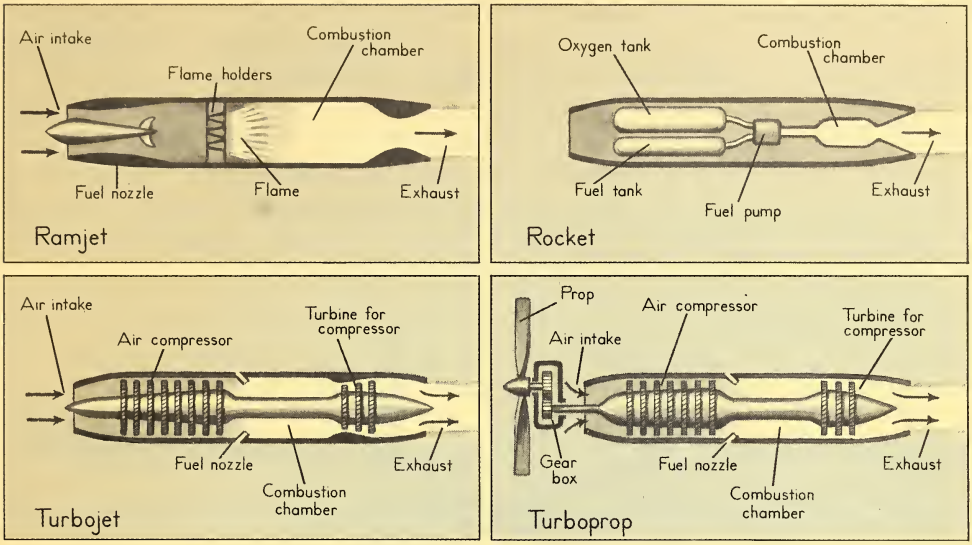
ciple. A gas lighter than air is used to fill the gas compartment. Hydrogen is the lightest known gas, but it has certain drawbacks. It is highly inflammable and therefore dangerous. Helium is a better gas to use in these lighter-than-air craft. Helium is only slightly heavier than hydrogen and is not inflammable.

On page 236 of *Experimenting in Science* the distinction is made between aircraft lighter than air and heavier than air. The Wright brothers built and flew the first successful heavier-than-air craft. Their original plane weighed approximately 800 pounds. This is a far cry from the tremendous weights of present-day airliners, many of which weigh more than 130,000 pounds. However, in each type of heavier-than-air craft the lift is provided by the wings. It is the wings of a plane that make flying as we know it possible. This is the principal concept developed on page 237 of the text. The experiment on page 238 develops the concept that fast-moving air has less pressure than slow-moving air. In the experiment on page 239 the concept of wing design is related to fast-moving air to show how a wing provides lift for the plane. The illustration on page 237 will help with this experiment. It shows that air moving over a wing has a farther distance to travel than the air under the wing. So the air over the wing moves faster. The faster-moving air has a lower pressure than the slower-moving air below the wing. The greater air pressure below the wing provides the lift.

On page 240 of *Experimenting in Science* the concept of the propeller as a screw is developed. The propeller gives the plane its forward thrust through the air. A plane with a fixed wing must move forward at a speed great enough for the air to move fast enough over the wing to provide lift for the plane.

On page 241 the concept of propellerless planes is introduced. These planes are usually called jet planes because the forward thrust is provided by a jet of hot expanding gases escaping from the plane's engine.

There are various types of jet planes. The jet engine shown on page 242 of *Experimenting in Science* is a turbojet. There are other jet engines, such as the ramjet and the turboprop. Air is scooped into the front opening of the ramjet engine as the plane moves forward through the air. Air is brought into the engine of a turbojet by a system of fans. A turbojet with a propeller is known as a turboprop. The propeller is not absolutely necessary, but it has certain advan-

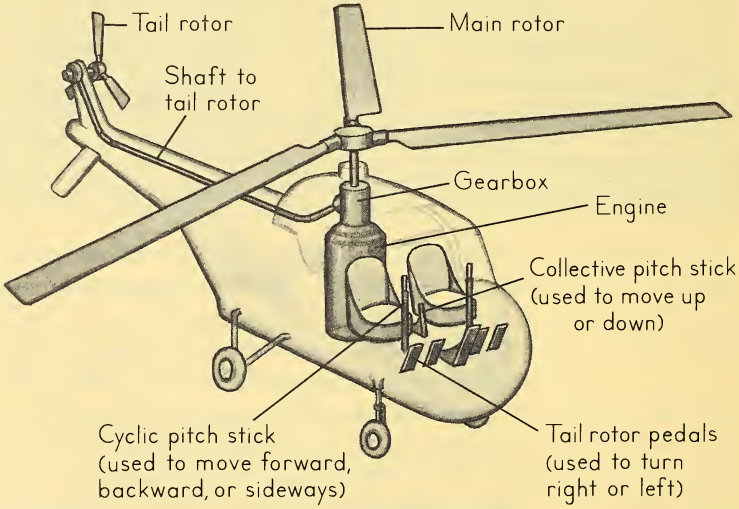


tages when combined with a jet engine. Such a combination of jet and propeller uses less fuel and gives the plane a longer flying range. Jets with propellers also have better-controlled take-offs and landings because the take-off and landing speeds are slower. Rocket planes differ from jets in that they carry their own oxygen supply.

The concept of balance among forces affecting a plane is discussed on pages 243, 244, and 245 of the text. Gravity operates on all objects so as to pull them toward the earth. The counter force to overcome this is that of lift which is provided by the wings of the plane. In order to keep a plane in the air, the lifting force must be greater than the gravitational force operating to pull the plane to the earth. Thrust is the name given to the force which propels a plane forward. The counter, or opposing, force is called drag. Just as its name implies, this is the force that tends to hold the plane back or makes it difficult to move the plane through the air. Drag is the result of friction between the plane's surface and the air through which it is moving. The flight of the plane is controlled by careful balancing among these four forces.

The section on helicopters beginning on page 248 of *Experimenting in Science* is designed to be provocative as well as informative. The concept is developed of the helicopter as a type of aircraft which

has moving wings. In the diagram below you can see a view of the construction and curvature of helicopter blades. Air is moved over these surfaces by the rotation of the blades. Lift is provided by the difference in air pressure above and below the blade surfaces. The faster the blades are rotated, the faster the air moves over the surface of the blades, or moving wings. The speed of the air moving over the blades helps to control the rise and descent of the helicopter. The material in the text on heliports can provide an important point of departure for discussion.


Tail rotor
Main rotor
Shaft to tail rotor
Gearbox
Engine
Collective pitch stick (used to move up or down)
Cyclic pitch stick (used to move forward, backward, or sideways)
Tail rotor pedals (used to turn right or left)

On page 250 of *Experimenting in Science* we begin our journey into outer space. This concept is approached through some of the problems which must be met as man journeys into space. Oxygen to keep the human body alive is of prime importance. The lack of oxygen in outer space presents a problem of engine design too. This is being met through continued development of rocket engines.

Ways of Working with Children

Simple, illustrative experiments and demonstrations provide an opportunity for small-group activity. Certain groups may wish to take the initiative in performing the experi-

ments. They may act as group leaders in aiding others to perform the experiments.

A committee of children may undertake to write to or visit a commercial airline to procure information. Many times excellent diagrams of planes, maps, and other material may be secured in this manner. Such a committee may also make preliminary arrangements for a field trip to an airport.

One can often locate a person in the community who holds a pilot's license. Usually such a person is only too willing to serve as a resource person for your group. The children can learn a great deal about the practical end of flying from such an individual. Another type of resource person is one who has served with the Air Force. Insights concerning military aviation can be provided by such a person.

Many airplane manufacturers supply material on their products. This material can be very useful as an additional source of information. Special-interest groups or a committee may undertake to write to the manufacturers and secure this material. Addresses can easily be secured from advertisements in popular magazines. Pertinent material can also be obtained from the National Aviation Education Council, 1115 17th Street NW, Washington 6, D. C. and the Aircraft Industries Association of America, Inc., 610 Shoreham Building, Washington 5, D. C.

The children should be encouraged to secure current information concerning air travel, as well as space travel, from newspaper, radio, and television reports. These sources will be especially important with respect to pages 246 and 247 of *Experimenting in Science*. The travel time between the cities listed on the map on page 246 will decrease as the flying speeds increase.

The section on helicopters can provide for very stimulating discussion and research. The helicopter is coming into its own. The heliport has many advantages over conventional airports. You might raise such a topic for the group to discuss and look into. Much material can be found on potential uses for the helicopter. Information of this nature will be supplied by helicopter manufacturers. Many airlines are considering instituting helicopter service for short trips up to 250 miles. If this were to happen, it would revolutionize our concept of transportation.

Much of the information children are getting concerning space

travel is fictional and inaccurate. The section beginning on page 250 of the text attempts to take a realistic look at a few major problems. This section can be extended by discussion and research on the part of the children. They may want to look into some of the notions of space travel which are current in television and radio programs and science fiction. They can be encouraged to take a realistic look at these notions. Above all they should be encouraged to question these sources and to look for reliable information. They will begin to see that the truth is as fascinating and challenging as the fiction which permeates much that is being put before them. You may want at this time to refer again to the material on outer space on pages 132–134 of *Experimenting in Science*. This will help you to relate their present concepts of outer space to those which they formulated earlier. Is the concept of the darkness of outer space part of their thinking?

The children may undertake to make a chart of some of the ideas which they have found concerning space travel in a survey of radio, television, and the movies. The chart should also contain an evaluation of the information. Is it accurate? If it is not, in what way is it inaccurate? On what do they base their analysis? As you can see, such an undertaking will entail a good deal of research and original work on the part of the children. Such an undertaking can be challenging as well as rewarding.

Materials Needed

balloon

paper, 2 pieces 6 inches square, and 1 piece 2 inches wide and 6 inches long

paste

pencils, 2

screw

screwdriver

soda straws, 1 for each child

wooden stand

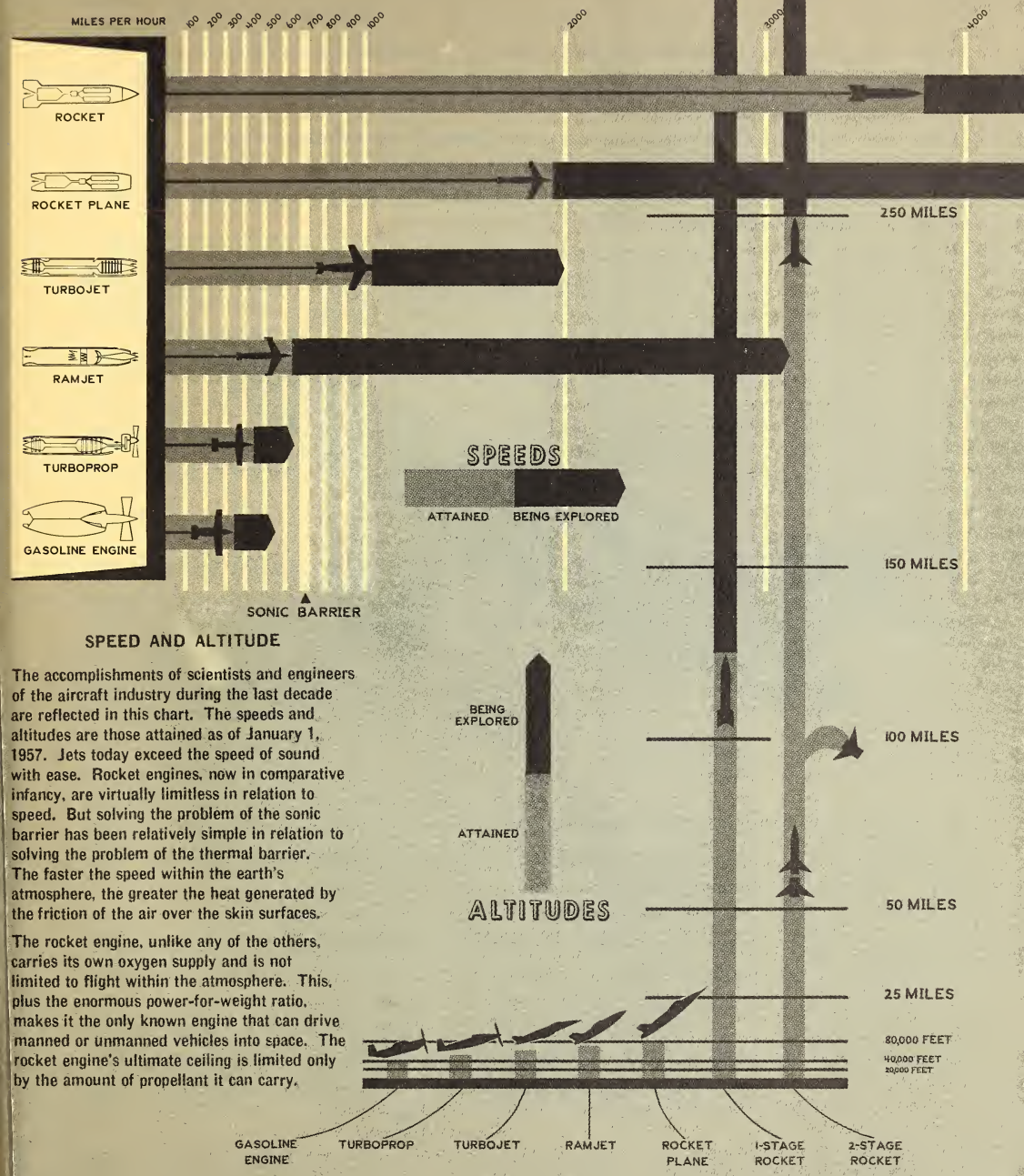
Learning More about Flight

See suggestions for children, page 255, *Experimenting in Science*.

1. This information can be found in encyclopedias and biographies about each of these people.

2. A field trip should, of course, be carefully planned. Preparation for the trip should include a discussion of what the children

SPEEDS AND ALTITUDES OF PLANES AND ROCKETS



SPEED AND ALTITUDE

The accomplishments of scientists and engineers of the aircraft industry during the last decade are reflected in this chart. The speeds and altitudes are those attained as of January 1, 1957. Jets today exceed the speed of sound with ease. Rocket engines, now in comparative infancy, are virtually limitless in relation to speed. But solving the problem of the sonic barrier has been relatively simple in relation to solving the problem of the thermal barrier. The faster the speed within the earth's atmosphere, the greater the heat generated by the friction of the air over the skin surfaces.

The rocket engine, unlike any of the others, carries its own oxygen supply and is not limited to flight within the atmosphere. This, plus the enormous power-for-weight ratio, makes it the only known engine that can drive manned or unmanned vehicles into space. The rocket engine's ultimate ceiling is limited only by the amount of propellant it can carry.

want to see and do at the airport. They may want to see the inside of a plane, the instrument panel, the weather station at the airport, to become familiar with the various parts of a plane, etc.

3. Barriers such as mountains no longer isolate a people or a nation.

Much of our goods and products are shipped by air.

Crops can be dusted by low-flying planes.

Fire fighters can be dropped to any part of a forest quickly to fight fire.

Transportation would be less rapid if there were no airplanes.

A much greater and more detailed list can be developed through ample discussion by your children. The above list is only suggestive of some points which you may use to stimulate discussion.

4. You might encourage some of the children to bring model airplanes to school. They may have constructed them at home. Some boys may have gasoline models and gliders. These children can act as resource people for your group.

Further Activities

1. Have the children do research on balloons and dirigibles. Balloons are used to get information concerning the upper atmosphere. What are some other uses of lighter-than-air craft? What comparisons might be drawn between helium and hydrogen? You might also encourage the children to search out some of the reasons balloons and dirigibles have never been adopted as general means of transportation. Dirigibles have an interesting history. Many disasters centered around dirigibles during the 1920's and 30's.

2. An interesting mural can be constructed depicting the history of aviation, from the earliest attempts to imitate the flight of birds, to balloons, dirigibles, the first heavier-than-air craft, and the rocket-powered aircraft of today.

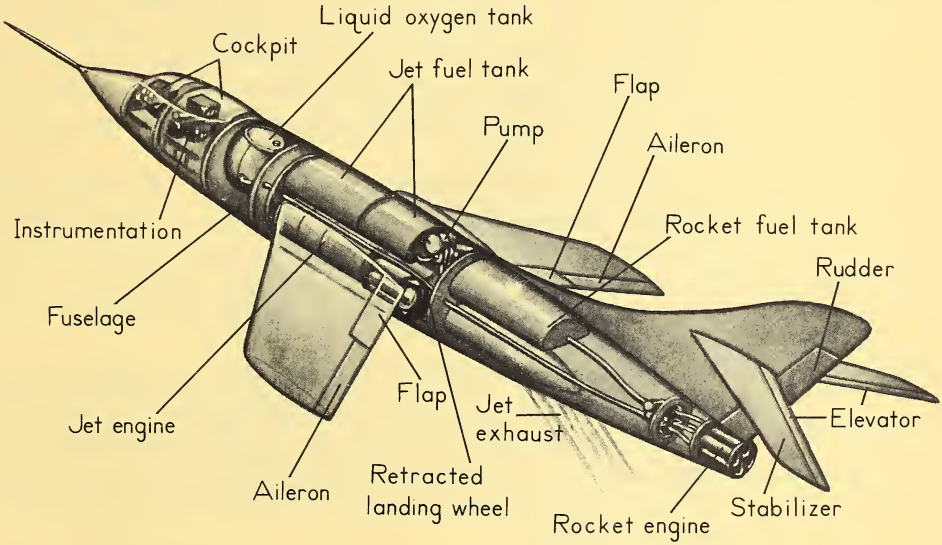
3. Some students may wish to study airplane design. They can show by pictures, drawings, and photographs how airplanes have been designed to overcome drag. They can contrast early planes with more-recent streamlined aircraft.

4. A group of students may undertake to make a report on various methods of navigating a plane. The pilot can fly by: (1) dead reckoning; (2) radio navigation; (3) celestial navigation. These

methods are described in *Flight Today and Tomorrow* by Margaret O. Hyde.

5. Three important control devices on a plane are the rudder, elevator, and ailerons. One or more children might construct a model airplane which will illustrate how these parts work. The model should show that:

(a) the rudder turns the plane;
(b) elevators make the plane nose up and down;
(c) ailerons tilt the plane to the right and left.



6. Rockets have a long history. The Chinese were probably the first to build a rocket more than 700 years ago. Rockets have been used in many countries and for many different purposes. In the 18th century they were used in India against the British. Since that time they have been used by almost every army. The U. S. bazooka, the German V-2, and the airplane called the Douglas Skyrocket are all rockets in principle. The Douglas Skyrocket uses both jet and rocket engines. Much interesting material can be gathered concerning the history of rocket developments as well as the important part that rockets will play in space travel.

Evaluation

The process of evaluation should give us a means of appraising the effectiveness of the experiences the children have had. One of the stated objectives of this chapter has been to provide a reliable source of information concerning some common challenging concepts of air travel as we know it today and as it may be in the future.

A test of the effectiveness of the child's study of this material should be whether he questions erroneous and fictitious notions with which he is confronted in class or during the course of his daily living. Is he selective? Does he make judgments on the basis of reliable information when he has it available? During discussions does he challenge a statement and call for evidence or does he accept ideas without questioning or asking the source? When questions arise, does he go to reliable sources for answers? How does he report the results of such research?

The use of creative imagination is important. The section of this chapter beginning on page 250 of *Experimenting in Science* should be stimulating in this respect, since it deals with problems of space travel. However, when the children imagine and speculate, do they base their speculation on reliable information and evidence or is it merely wild and fanciful?

Have the children gained in their ability to raise significant questions about a particular topic such as travel to and from the moon? Do they sometimes wait for someone to supply the answers to such questions to them? To what extent do they themselves employ the tools of research, such as reading, to find answers to the questions they have raised?

Have the children grown in their ability to present their ideas during discussions? Are they able to say what is right *not* who is right? If so, this is a sign of growing maturity.

Bibliography

For the Teacher

Blough, Glenn O., and Huggett, Albert J. *Elementary-School Science and How to Teach It*, Chapter 24. The Dryden Press, 1951.

Craig, Gerald S. *Science for the Elementary-School Teacher*, New Edition, Chapter 12 (see also pages 705–707). Ginn and Company, 1958.

Fay, John. *The Helicopter and How It Flies*. Pitman Publishing Corporation, 1954.

Shippen, Katherine B. *Bridle for Pegasus.* The Viking Press, 1951.

Wright, Orville. *How We Invented the Airplane.* David McKay Company, Inc., 1953.

For the Children

Beeler, Nelson F., and Branley, Franklyn M. *Experiments with Airplane Instruments.* Thomas Y. Crowell Company, 1953.

Bendick, Jeanne. *The First Book of Airplanes.* Franklin Watts, Inc., 1952.

Bendick, Jeanne. *The First Book of Space Travel.* Franklin Watts, Inc., 1953.

Clarke, Arthur C. *Going into Space.* Harper & Brothers, 1954.

Cooke, David C. *How Airplanes Are Made.* Dodd, Mead & Company, Inc., 1956.

Cooke, David C. *Young America's Aviation Manual.* The McBride Company, 1954.

Hyde, Margaret O. *Flight Today and Tomorrow.* McGraw-Hill Book Company, Inc., 1953.

Lewellen, John B. *Helicopters; How They Work.* Thomas Y. Crowell Company, 1954.

Lewellen, John B. *Jet Transports.* Thomas Y. Crowell Company, 1955.

Ley, Willy. *Engineers' Dreams.* The Viking Press, 1954.

Moore, Patrick. *The Boys' Book of Space.* Roy Publishers, 1956.

Neurath, Marie. *Rockets and Jets.* Lothrop, Lee & Shepard Company, Inc., 1952.

Parker, Bertha M. *The Sky above Us.* Row, Peterson and Co., 1953.

Poole, Lynn. *Your Trip into Space.* McGraw-Hill Book Company, Inc., 1953.

Ross, Frank, Jr. *Young People's Book of Jet Propulsion.* Lothrop, Lee & Shepard Company, Inc., 1954.

Schneider, Leo, and Ames, Maurice U. *Wings in Your Future.* Harcourt, Brace and Company, 1955.

Films

AIR ALL ABOUT US. (Cor) 1 reel, b/w & color. Explains the use of air pressure in suction cups, bicycle and automobile tires, a car lift, and airplanes.

AIR IN ACTION. (Cor) 1 reel, b/w & color. Presents the basic concepts of the effects of bodies moving through air and the effects of moving air on stationary objects.

AIRPLANES AND HOW THEY FLY. (YAF) 1 reel, b/w. An elementary presentation of the principles of aircraft flight with illustrations of types of modern planes.

PIONEER OF FLIGHT. (TFC) 1 reel, b/w. Stressing scientific method this film tells the life story of John J. Montgomery who first made and flew a glider in controlled flight. Emphasizes his contribution to the development of aviation.

Filmstrips

Air and Its Properties. (YAF) b/w.
Airplanes and How They Fly. (EGF) color.
Friction at Work. (YAF) color.
Our Ocean of Air. (SVE) b/w.
Using Air Pressure. (VS) color.
What Air Does. (VS) color.
What Air Is. (VS) color.
What Air Pressure Is. (VS) color.

XII

Making the World a Healthful Place

In this chapter some of the major problems of community health are discussed. The emphasis is on the child and his own personal behavior and experience with certain community health problems. Getting a supply of water for drinking and for a variety of household and community purposes is of major concern to a community. The efficient and safe disposal of sewage and other wastes is another primary concern for a community if it is to remain healthy. More and more attention is being devoted to the air with which man is surrounded. So the air we breathe is also considered as a fundamental part of community health in this chapter. Recognition is given to the fact that communities are not all alike and because of this their answers to the problems of community health vary. The child is encouraged to examine his own home and his own community. To each of the problems several possible solutions are indicated, each of which can contribute to a clean, pleasant, and healthy community.

Science Meanings for Children

A major facet of elementary-school science has to do with behavior. We want the children to have a genuine concern for their environment. They should be sensitive to the conditions of health which surround them. A feeling of responsibility should grow out of this concern for their environment. The following concepts deal with aspects of community health. Ideally, the study should be one which leads out to their own community. These concepts are intended as a background against which present community practices may be viewed and studied:

Everyone must have water for drinking, bathing, cooking, and many other purposes.

All our water supplies are the result of rain, snow, sleet, or hail.

The water which moves along or collects on the surface of the land is called surface water.

We should be cautious about using surface water, because it is easily polluted.

Water stored in the soil and in certain layers of rock below the surface is called ground water.

We are always looking for better ways of collecting and storing the water which falls on the earth.

Some cities draw their water supplies from underground.

Water from artesian wells will usually flow to the surface without the need for pumping.

The presence of an artesian water supply depends on very special rock conditions. An artesian system is like a huge underground reservoir.

Our underground reservoirs may become some of our most important sources of water.

An ordinary well is usually dependent on the amount of rainfall in its immediate vicinity.

People who use water from their own wells should have the water tested from time to time.

Water containing impurities must be purified before it is used for drinking.

In many communities, all the drain pipes in the city lead to a sewage-disposal plant where the sewage is treated to make it harmless.

In many communities each house disposes of its own wastes on its own property. The cesspool and the septic tank are two kinds of private sewage-disposal system.

Much of our kitchen wastes are the remains of animals and vegetables which were raised for food. Kitchen wastes also include the containers in which the food was packed.

Refuse may be disposed of by the sanitary-landfill method or by incineration.

Impurities in the air we breathe are a serious community problem.

Man can change his community for better or for worse. We all have a part in building this world!

Information for the Teacher

The subject matter of this chapter revolves essentially around water: having a pure water supply, getting it into the home, using it for drinking, washing, and preparing our foods. Having procured and used the water for these various purposes, we are then led to disposal problems.

On page 257 of *Experimenting in Science* a look is taken at the community as a whole. The problem of water procurement and waste disposal is raised. Water procurement is really a national problem. Large urban concentrations place a terrific demand on the available water. Great quantities of water are needed in rather limited areas.

Cities located near large bodies of fresh water, such as a lake or river, have water available in quantity. However, the water is more than likely unsafe and not fit for human consumption. The water is usually polluted by the very fact of being near the city. The common practice in the past was to dump wastes and raw sewage into any body of water which was convenient to a city.

It is frightening to consider that more than half the population of North America lives in communities that do not have sufficient and wholly-safe water supplies. We have the means and know-how to provide adequate and safe supplies of water for every person in every community. Steps are being taken in almost every state and province, but truly adequate solutions will follow only as the public as a whole becomes more sensitive to the need.

On page 259 of *Experimenting in Science* the concept of the origin of water supplies as the result of rain, snow, sleet, or hail is developed. Water falls to the surface of the earth as rain or some other form of precipitation. Then it either flows along as surface water or sinks into the soil and rock and becomes ground water. Implied in this is the fact that water is continually evaporating, day in and day out, from all the bodies of water over the entire earth.

On pages 260–264 of *Experimenting in Science* the principles of utilizing underground water are discussed. The discussion centers around two types of wells: the artesian well and the ordinary well. A simple demonstration on page 261 illustrates how water rises in an artesian well.

A very important point with reference to artesian supplies is

made on page 262. This is that an artesian system is like a huge underground reservoir. Three separate rock layers make an artesian supply possible. The middle layer of rock must be porous, and this provides us with a ready-made means of water storage. There is the possibility that man can make use of these underground reservoirs by artificially filling them by pumping surface water into the porous rock layer. This would provide man with an economical way of storing water until it is needed.

For most cities, carefully planned water systems must be constructed. Water may have to be obtained from a river, lake, or mountain stream. Some cities are far from their source of water. The water may have to be transported through pipes a distance of one or two hundred miles.

Artificial lakes, called reservoirs, are built by many cities to catch and store water from a watershed area. Los Angeles, New York City, San Francisco, and Jersey City are among the cities which derive their water from reservoirs. Among the cities that take their water from lakes are Toronto, Detroit, Milwaukee, Buffalo, Cleveland, and Chicago. River water is another common source of water for cities. St. Louis, Quebec, Atlanta, and New Orleans tap rivers for their water supply.

The water derived from surface sources such as rivers, lakes, and mountain streams has impurities in it and is to varying degrees polluted. It certainly is not safe to drink such water before it has been purified. Many diseases may be contracted from impure water. Among two of the most common of these diseases are typhoid fever and dysentery. Water purification is one major aspect of the problem of maintaining community health. On pages 265 and 266 of the text there is a description of the way one city purifies its water to make it safe to drink.

On page 267 of *Experimenting in Science*, the problem of stream, river, and bay pollution is opened up. The description centers around what actually happened in one town on the east coast during the space of less than thirty years. Many states now have laws regulating sewage disposal and by this means they are able to set up controls against stream, river, and bay pollution. It is unfortunate and a sad commentary on the situation that many cities have undertaken proper disposal of sewage only after threat of court action.

A city sewage-disposal system is described on pages 268 and 269

of *Experimenting in Science*. Each city, of course, has its sewer lines located beneath the city streets. The drain pipes and sewer lines of each home and building are connected with the sewer lines which run under the city streets. These sewer lines are all connected with other lines which carry the sewage away. In many cities these lines lead to a sewage-disposal plant. The sewage-disposal plant described on page 268 is only one type. There are many different types, but in principle they all accomplish the same thing: effective treatment of sewage to make it harmless.

Cesspools and septic tanks are described on pages 270 and 271 of the text as effective means by which individual homes may dispose of sewage.

Wherever man lives, waste materials accumulate. Much of the wastes are the remains of animals and vegetables which are used for food. Containers such as tin cans, bottles, and paper in which the food has been packed also add to the waste. The efficient and safe disposal of such waste material is very important to the health of the community. On pages 271, 272, and 273 of *Experimenting in Science* various procedures for the safe disposal of such refuse is discussed. In the discussion of incinerator plants the idea of conservation is important: the salvage of fats, fertilizer material, paper, rags, metals, and glass. The emphasis here is on a fuller use of materials.

The section on pages 274 and 275 of the text deals with the air we breathe. This has become an increasingly vital facet of community health. We are hearing a great deal about impurities and

Courtesy of Allegheny Conference on Community Development

These photographs show the city of Pittsburgh before and after smoke-pollution control.

other materials in the air that surrounds us. Many respiratory diseases and conditions of the eyes and other organs of the body are probably due to impurities and other contaminating materials in the air. These impurities in the air can also affect plants and animals. An attempt has been made to have this section informative and constructive in outlook. Above all, the idea should stand out that man can by positive action alleviate the menace of impurities in the air that surround us and invade our bodies.

Ways of Working with Children

Each community is unique. Some major aspects of community health are discussed in this chapter. However, solutions to these problems can and do vary. Preliminary questions might be raised with the children. How do we do these things in our community? What are the safeguards we have in our community? This might very well lead to a survey of the community to gather information on the pertinent problems.

Each of the following questions could be the focus for a major undertaking by a committee or by the whole class:

(1) What is the source of our water? Do we get it from a lake, a river, a system of mountain streams, from artesian wells, or ordinary wells?

(2) How do we purify our water? How is our water tested?

(3) What kind of sewer system do we have?

(4) How do we dispose of our sewage?

(5) How do we make sure our sewage is not a source of contamination to humans, animals, and bodies of water in our vicinity?

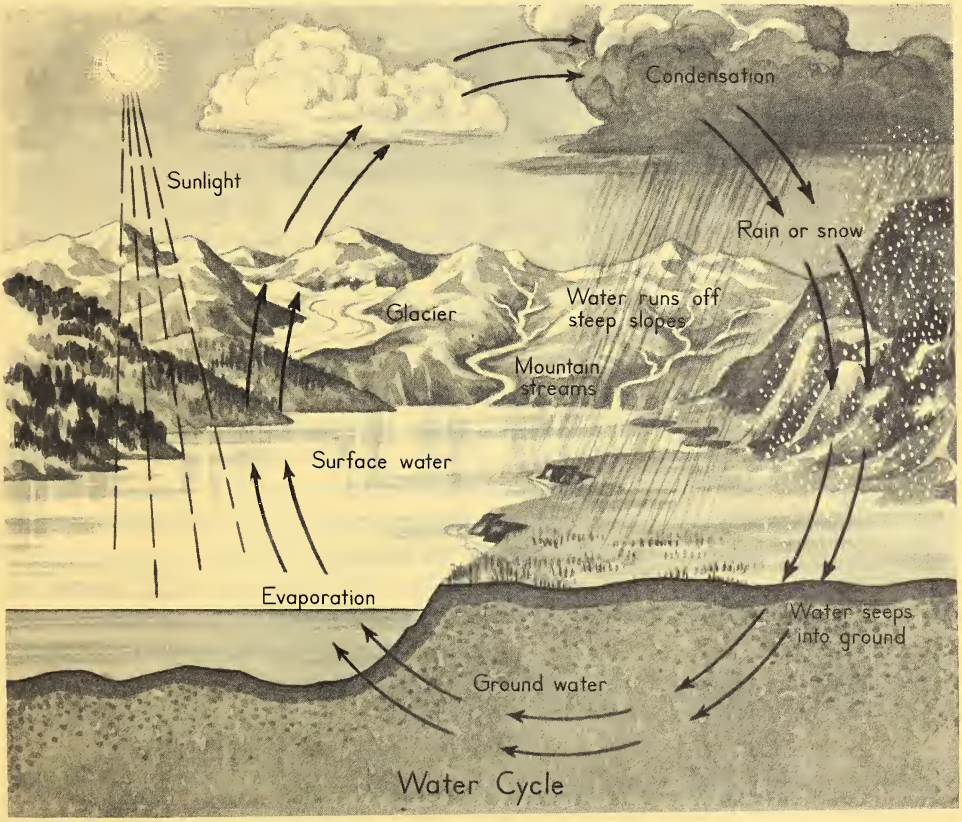
(6) How do we dispose of our garbage?

The group would have to formulate plans concerning how they would gather the information. As they formulate these plans, questions such as the following might be raised: What agencies could we go to for help in gathering this information? What people in the community could be called upon to act as resource people for our group? The information could form the basis for a mural or even individual dioramas depicting how these problems are met in your community.

The information contained on page 259 of *Experimenting in*

Science could form the basis for a chart of a water cycle. The chart could be made with a local setting. Evaporation could be depicted as occurring from the bodies of water in or near your vicinity. The children might also do some research to find out what the average precipitation in your vicinity is for a year. They might also attempt to learn from the local or state Weather Bureau what per cent of this is rain and what per cent is snow and other forms of precipitation. How is the precipitation distributed over the year? Does a lot fall during the summer months? Are there heavy spring runoffs?

If your community has a sewage-disposal plant, you might plan a field trip to see it in operation. Possibly a chemist at the plant will show you some of the tests which he makes.



You might have a group try to locate information on artesian supplies. The state geologist or Water Department can probably indicate if there are any artesian wells in your vicinity. You might plan to visit such a well.

On page 158 of this Manual, lists of cities are given with the source of their water supplies, that is, lake, river, reservoir. The children might locate and identify some of the lakes and rivers from which water is taken. They could also secure information concerning the watershed areas from which various cities draw water by writing to the Water Departments of those cities. This information could be entered on a large map of North America. This map can be as detailed as you and the children desire to make it. Detail as to topography and other information would of course require research on the part of the children. This could profitably be tied in with the discussion of rainfall on pages 151–156 of *Experimenting in Science.* The maps on pages 152 and 155 may also be helpful.

On page 273 of *Experimenting in Science* it is pointed out that a variety of materials can be salvaged from refuse. You might have the children keep a record for a period of a week or so of the various types of materials that are thrown away at home, in the school cafeteria, and a few other places in town such as a vegetable market, butcher shop, factory, etc. This will point up the wealth and variety of materials which are lost to us in our garbage pails and waste baskets.

Ample time should be taken to set up discussion groups. Have the children go to newspapers and other sources to gather information on what is currently being done throughout the world on these problems. *The World Almanac* has informative tables and figures on dams and reservoirs. Information on the development of water sources will be available in the newspapers. Information might also be procured by writing to the consulates of various nations in this country. For example, Afghanistan is one country in particular which has a long-range program in operation for the development of water sources. Initial work on this problem was begun in that country in the middle and late 1940's. The work is still progressing. Gathering such information is a type of activity which will help the children to get a broad perspective on the problems involved.

Another important survey of the community which children can make is one to find out the kind of impurities which are likely to be

in the air. The local Board of Health is a good agency to turn to for help in this matter. However, an inspection of the community will point up many sources which are pouring impurities into the air. Many impurities may travel into your community via air-mass movements. From what direction are the prevailing winds in your community? That is, where does your air come in from? What happens when the wind shifts? Are impurities coming to your community from another community which is nearby? Is anything being done in your community to prevent the escape of impurities into the air?

Materials Needed

bricks, 6 or 8
can opener
carpet tack, large
clay or Plasticine
cork
flowerpot, small
rubber tubing, piece about 3 feet long
tin cans, 2 large
water

Learning More

See suggestions for children, page 276, *Experimenting in Science.*

1. The pictures will depend on how the water supply of *your* community is made safe. This will require a study of the community water supply.

2. Typhoid and dysentery are two of the primary diseases spread by water. The bacteria causing these diseases are carried in impure water and enter our bodies when we drink the water. About a hundred years ago typhoid fever was a great killer in both urban and rural areas. Men studying this disease found that typhoid bacteria were present in the intestines and bladder, and as a result in the feces and urine of the affected person. Drinking water became infected when human wastes containing the bacteria entered the water. A great deal of material is available on water, its purification, and the diseases carried and spread by it. A report on diseases carried by water can take many different forms and be as elaborate as the reporter wishes to make it.

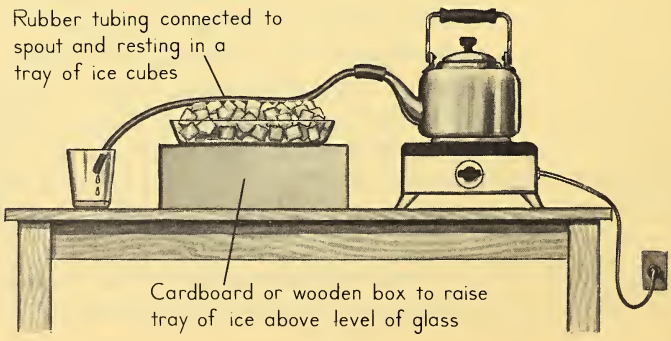
3. This map will depend on your community and the quality of your survey. A careful survey will give the children an opportunity

to put some of their information into action. In most communities the Board of Health is most co-operative in such an undertaking. In many communities the Junior Chamber of Commerce sponsors a Clean-Up Week. The activities of the class could mesh in very nicely with such a campaign.

4. The activities of the World Health Organization are quite varied. They have done a great deal in the underdeveloped areas of the world to raise the health standards. Trained specialists have been sent into the areas to work with the local people. A committee of children might undertake to write to the information service of the United Nations for a detailed account of the undertakings of the World Health Organization. This organization will supply information on projects completed as well as on those presently being undertaken.

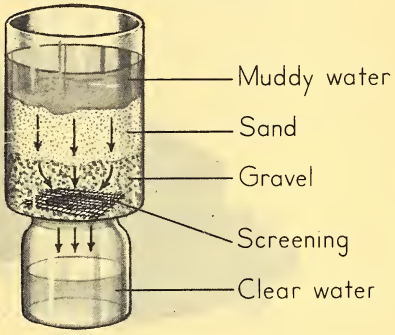
Further Activities

1. Salt and other impurities are left behind when ocean water evaporates. Have the children place a tablespoonful of salt in clean water and taste it. It is salty, isn't it? Then place the water in a teakettle. This kettle should have a spout. A piece of rubber tubing should be attached to the spout. Cover this tubing with ice cubes. The free end of the tubing is placed in a glass. Boil the water by placing the teakettle on a hot plate. As the water boils, tiny drops of water will collect in the glass. The water evaporates from the teakettle. The vapor enters the rubber tubing. The ice surrounding the tubing cools the vapor so that it condenses to liquid water.


Rubber tubing connected to spout and resting in a tray of ice cubes
Cardboard or wooden box to raise tray of ice above level of glass

Eventually all the water will evaporate from the kettle. When the children examine the kettle, they will find that the salt has remained. The water which collected in the glass does not taste salty. This is somewhat similar to the evaporation and condensation which takes place from bodies of water all over the earth. Salts and other impurities are left behind as the water evaporates and enters the air.

2. A group can make a small filtering system. Use a tin can which holds about $1\frac{1}{2}$ quarts. A round hole should be cut in the bottom of the can and a piece of screening placed over this hole. Over the



screening, place a layer of gravel. The screening is just to give a base to hold the gravel. On top of the gravel place a layer of sand. Each layer should be about 2 inches deep. Add a tablespoonful of soil to about 1 pint of water and mix it. Now you have some muddy water. Pour this water over the top of the sand in the "filter bed" and collect the water that drips through. The filtered water will have lost some of its mud. *However, the children should not drink this water.* It will still contain many harmful bacteria which were in the soil. In the process of making water pure, chemicals are added to kill the harmful bacteria.

3. Have the children boil some water for ten minutes or more. When the water has cooled, they should taste it. It will probably have a flat taste because the air has been forced out of the water during the boiling process. Pour some of the boiled water back and forth between two clean glasses. This allows air to enter the water and is called aerating the water. It can then be tasted again. It will probably taste much better. Aeration is an important part of the process of purifying water and helps to improve its taste.

4. Secure a copy of the health regulations which are enforced in your town or city. The local or county Board of Health can supply a copy of these regulations. How do these regulations help to protect our health? The school nurse or school physician will help you with some of the reasons for the regulations.

5. The children might examine a bottle of Chlorox or other bleaching compound. You will notice that it contains sodium hypochlorite. This is a chemical compound containing chlorine. On the bottle there are directions for disinfecting drinking water. This can be used as an emergency measure when you are not quite sure that water is totally pure and safe. Thoroughly mix the Chlorox and water in the proper proportions. Do this mixing in a glass container. Certain metals are attacked by the bleaching agent. The disinfectant kills the harmful bacteria which might be present. This is something like the process by which cities purify their water by adding chlorine to it. Chlorine tablets can also be purchased at drugstores for the same purpose. Directions are given on the container as to the quantity of water to which the tablets must be added and the manner in which they should be added. All these measures help kill the harmful bacteria which may be contained in water of whose purity we are not sure.

Evaluation

Item 3 under *Learning More* on page 276 of *Experimenting in Science* suggests that children might map breeding places of insects in the community and that this be followed by consultation with the Board of Health to determine what action the children themselves might undertake to help abolish these undesirable places. This type of activity indicates the theme by which the effects of the learning might be evaluated. You might ask yourself the following questions:

1. Are the children able to translate concepts into action?

2. Do these concepts of community health become a real part of their patterns of thought and behavior?

3. Do the children show an increased concern about the health aspects of their community?

4. Do they spontaneously suggest and undertake small jobs which will contribute toward the health of the whole community?

There are many opportunities in the study of this chapter for the children as individuals and as a group to gather information by actual survey, interview of various people and agencies, and by reading and research. Were they successful in their quests for information? Did they display a measure of initiative in securing information? What were some of the good features of their procedure? What features and methods do they need to improve? You might help the children evaluate their procedures. Self-evaluation is an important part of the learning process.

During discussion, either free or of the panel type, are they sensitive to the way the information applies to their own community? How well informed are they about health problems current in their own community? Do they feel a sense of responsibility for the improvement of any undesirable conditions which may exist?

Bibliography

For the Teacher

Craig, Gerald S. *Science for the Elementary-School Teacher,* New Edition, Chapter 21. Ginn and Company, 1958.

Peattie, Rod and Lisa. *The City.* Abelard-Schuman, Inc., 1952.

Smiley, Dean F., and Gould, Adrian G. *Your Community's Health.* The Macmillan Company, 1952.

Stefferud, Alfred (editor). *Water,* The Yearbook of Agriculture, 1955. United States Department of Agriculture.

Turner, Clair E. *Personal and Community Health.* The C. V. Mosby Company, 1952.

For the Children

Blough, Glenn O. *Not Only for Ducks: The Story of Rain.* McGraw-Hill Book Company, Inc., 1954.

Norling, Josephine S. and Ernest Ralph. *First Book of Water.* Franklin Watts, Inc., 1952.

Riedman, Sarah R. *Water for People.* Abelard-Schuman, Limited, 1952.

Schatz, Albert, and Riedman, Sarah R. *Story of Microbes.* Harper & Brothers, 1952.

Schneider, Herman and Nina. *Let's Look under the City.* William R. Scott, Inc., 1954.

Selsam, Millicent. *Microbes at Work.* William Morrow and Company, Inc., 1953.

Tannehill, Ivan R. *All about the Weather.* Random House, Inc., 1953.

Walsh, Mary Regina. *Water, Water, Everywhere!* Abingdon Press, 1953.

Films

How We Save Water. (BF) 1 reel, b/w & color. Shows the entire process of bringing water to various users, from its source in the mountains to the faucets in our homes.

The Invader. (PFC) 1 reel, color. Presents the problems threatening the existence of the salmon, emphasizing the pollution of waters by industrial plants and inadequate sewage disposal in cities.

Man's Problem. (EBF) 1½ reels, color. Makes clear our absolute dependence on an adequate supply of clear, fresh water.

Your Health in the Community. (Cor) 1 reel, b/w & color. Stresses the many services of a public health department and suggests how individuals may co-operate in their community health program.

Filmstrips

Community Sanitation. (YAF) color.

The Story of Underground Water. (EBF) color.

The Water We Drink. (YAF) color.

Appendix

Minimum Science Equipment

The materials listed are items that are suggested in *Experimenting in Science* and the Manual for carrying out science experiences and activities. The articles are generally available in the school, the children's homes, or local stores.

Baking soda
Balloons
Bit and brace
Blotting paper, or paper towels
Bowls
Boxes, wooden and cardboard
Bricks, 6 or 8
Broomstick, about 18 inches long

Can opener
Candles
Cardboard
Cellophane, red
Cellophane tape, colored
Chisel
Clay, or Plasticine
Common pins
Compass
Corks, assorted
Cotten, absorbent
Crayons

Dishes
Drinking glasses, or aluminum tumblers
Dry cells, 3 fresh and 2 used No. 6's

Electric light, such as table lamp
Electric-light bulbs, assorted, including several flashlight bulbs

Field glasses, or binoculars
Flashlight
Flowerpots, assorted

Geranium plants, 2
Globe, on a stand

Hammer
Hook, for pulley

Iron filings

Jars, glass, 1 with metal screw top

Knife
Knitting needle, steel

Lemon juice

Magnets, several bar and horseshoe, including at least 1 inexpensive horseshoe magnet which may be broken
Magnifying glass, or hand lens
Maps, of North and South America
Marbles, 30
Measuring cup
Measuring spoons
Measuring tape
Mirrors, pocket

Nails, assorted, including some sixty-penny
Needles, including 2 darning needles
Newspapers
Nut and bolt
Nutcracker

Onion bulb

Pail
Pans, assorted
Paper
Paper clips
Paste
Pencils
Pie plates, 2 glass or Pyrex
Prism, or cut glass
Pulleys, at least 2

Rope
Rubber tubing, about 3 feet long
Rulers

Sand
Scissors
Screwdriver
Screws
Seeds: bean, corn, grass, sunflower
Shoe boxes
Sockets, including 2 small porcelain, for flashlight bulbs
Soda straws, 1 for each child
Soil
Spoons, assorted
Spring balance
Stones, one dozen
String

Tacks, assorted
Tennis ball
Thermometers, 3 outdoor
Thumbtacks
Tin cans, assorted, including several large, and 1 with cover
Toothpicks

Watering pot
Wheels, 1 each of 2 different sizes, such as 6 inches and 1 foot in diameter
Wire, insulated copper and iron
Wood, assorted pieces, including 1 board $\frac{3}{4}'' \times 3'' \times 3'$, and 1 block $2'' \times 4'' \times 6''$

Yardstick

Additional Science Equipment

The following items, while not essential, considerably enrich the program.

Bulbs, of plants

Camera, and films
Chlorox, or other bleaching compound
Coal
Copper sulfate
Copper wire, uninsulated
Corms, such as crocus and gladiolus

Doorbell

Egg beater
Electric switches

Food coloring, red
Fossil collection

Gloves
Gravel

Hot plate, or Sterno

Luminous sky charts

Marble, piece highly polished
Microscope
Models of airplanes

Paper for murals and booklets
Papier-maché
Poster paints and brushes

Rocks, or bricks weighing about 100 pounds in all
Rootstocks, such as dahlia

Salt
Scales, bathroom
Screws, machine
Seeds: clover, radish, wheat, and others
Shovel
Sulfur
Teakettle
Telescope
Thermometer, clinical
Tubers, such as sweet potato

Wagon

Wall hook
Wedges, assorted
Wire and wood to build a check dam
Wire screening
Wire shears
Wooden stand
World map

Equipment Supply Houses

CAROLINA BIOLOGICAL SUPPLY COMPANY, Elon College, North Carolina.
Living and preserved materials, plastic mounts, charts, and apparatus.

CENTRAL SCIENTIFIC COMPANY, 1700 Irving Park Boulevard, Chicago, Illinois; 237 Sheffield Street, Mountainside, New Jersey; 79 Amherst Street, Cambridge A Station, Boston, Massachusetts, *or* CENTRAL SCIENTIFIC COMPANY OF CALIFORNIA, 6446 Telegraph Road, Los Angeles 22, California, *or* REFINERY SUPPLY COMPANY, 2215 McKinney Avenue, Houston 3, Texas, *or* CENTRAL SCIENTIFIC COMPANY OF CANADA, LTD., 146 Kendal Avenue, Toronto 4, Ontario, Canada.
General equipment — hand lenses, reading glasses, copper bell wire, etc.

CHICAGO APPARATUS COMPANY, 1735–43 North Ashland Avenue, Chicago, Illinois.
General equipment—magnetism, heat, light, etc. Aquarium and terrarium supplies, living and preserved materials, charts, etc.

FISHER SCIENTIFIC COMPANY, 711–723 Forbes Street, Pittsburgh, Pennsylvania, *or* EIMER AND AMEND, 633–635 Greenwich Street, New York, New York, *or* FISHER SCIENTIFIC COMPANY, LTD., 904–910 Saint James Street, Montreal, Canada.
General laboratory supplies and appliances.

GENERAL BIOLOGICAL SUPPLY HOUSE, 8200 South Hoyne Avenue, Chicago, Illinois.
Aquarium and terrarium supplies, living and preserved materials.

NEW YORK SCIENTIFIC SUPPLY COMPANY, INC., 28 West 30th Street, New York 1, New York. (Formerly NEW YORK BIOLOGICAL SUPPLY COMPANY.)
Preserved and living materials, and chemicals.

PRACTICAL AIDS COMPANY, Estacada, Oregon.
General equipment.

SOUTHERN SCIENTIFIC COMPANY, INC., Atlanta 3, Georgia.
General equipment.

WARD'S NATURAL SCIENCE ESTABLISHMENT, INC., 3000 Ridge Road East, Rochester 9, New York.
Living and preserved materials and apparatus, rocks, and fossils.

W. M. WELCH SCIENTIFIC COMPANY, 1515 Sedgewick Street, Chicago 10, Illinois, *or* BRAUN, KNACHT-HEIMANN, 1400 16th Street, San Francisco 19, California.
General equipment.

Directory of Publishers

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